PEAR PRODUCTION

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On January 24, 1978, four USDA agencies—Agricultural Research Service (ARS), Cooperative State Research Service (CSRS), Extension Service (ES), and the National Agricultural Library (NAL)—merged to become a new organization, the Science and Education Administration (SEA), U.S. Department of Agriculture.

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PEAR PRODUCTION

By Max W. Williams, H. Melvin Couey, Harold Moffitt, and Duane L. Coyier[1]

INTRODUCTION

About 93 percent of the pear crop of the United States is produced in the three Pacific Coast States, California, Oregon, and Washington. Production there averages about 700,000 tons annually, as compared with about 750,000 tons for the entire United States. Varieties of high quality and European origin (*Pyrus communis* L.) are grown exclusively. The major pear areas of the Pacific Coast States are characterized by dry summers with abundant sunshine. In the better orchards, 30 to 35 tons of pears per acre are sometimes produced. The bacterial disease known as fire blight (*Erwinia amylovora* (Burrill) Winslow et al.), which makes it necessary to plant partly resistant varieties (generally of low quality) in most parts of the United States, can be controlled well enough on the Pacific coast to permit growing very choice varieties, even though they are susceptible.

CLIMATIC REQUIREMENTS OF PEARS

Although pears will tolerate a wide range of climatic conditions, their culture has been restricted mostly to areas that are particularly favorable for growing. On the Pacific coast, pears are important commercially from south-central California up into British Columbia. The southern limit of commercial pear growing is determined by the prevalence of high winter temperatures. The commercial pear varieties grown on the Pacific coast require a period of low temperatures (about 1,200 hours below 45° F (7.2° C)) during the winter to complete their dormant period.

Therefore, pears are not adapted for commercial production in sections where winter temperatures are so mild that the trees do not complete this period before blossoming.

Most pear varieties can withstand fairly low winter temperatures without much injury. If the trees are fully dormant, temperatures as low as -15° F (-26° C) do not cause serious injury. The wood and buds of pears are more subject to injury from low temperatures than apples under the same conditions. On the other hand, pears are more resistant to low temperatures than peaches.

All major pear areas of the Pacific coast are dependent on irrigation for moisture; consequently, rainfall does not determine the distribution of pear production. In other pear areas where natural rainfall is depended on for soil moisture, an average of at least 35 inches per year is desirable.

Air drainage and freedom from spring frosts are important in the location of a pear orchard. Pear trees bloom relatively early. If the dormant period has been completely broken during the winter, they normally bloom about 1 week before apples. The blossoms are about as easily damaged by spring frosts as are those of apples and peaches. Temperatures of 26° F (-3.3° C) or lower will generally kill the open blossoms. Therefore, because of the earlier blooming season, the hazards from spring frosts are greater for pears than for apples. In some areas

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pear orchards are equipped with heaters to protect the trees during the blooming season, particularly where orchards are located on lowland where air drainage is poor. Because of the adaptation of pears to fairly heavy soils, orchards have frequently been located on lowland.

The most serious disease in pear production is fire blight. On the Pacific coast this disease is most serious in the interior valleys, particularly in California and southern Oregon, where spring and early summer temperatures are high. In sections with cooler growing seasons, such as the coastal districts of California, the Williamette and Hood River Valleys of Oregon, and the Puget Sound section of Washington, pears are much less seriously affected by this disease.

Fire blight is the major hazard in growing pears in many areas of the East and particularly the South. In such locations it is necessary to select varieties that are at least partially resistant to this disease.

The climate has a definite effect on the quality of certain varieties. The Bartlett, which is the most economically important pear variety, apparently reaches its highest dessert and best shipping and storage qualities where temperatures are high for the 2 months preceding harvest. When grown in hot sections, this variety ripens more slowly after harvest, remains in prime eating or canning condition longer, and has less tendency to break down at the core than when it is grown in cooler sections. The Bosc, another important variety, also appears to reach its highest dessert quality where temperatures are high. The Anjou, the second most important commercial variety, is well suited to cooler conditions. This variety is well adapted to the moderately warm valleys of the Northwest. Average temperatures at typical points in important pear areas are shown in table 1.

Table 1.—Average growing season temperatures, by months, in commercially important U.S. pear areas

State and area	Station	Average temperatures in —													
		March		April		May		June		July		August		September	
		°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
California:															
Central	Auburn	51.2	10.7	56.1	13.4	62.4	16.9	71.4	21.9	77.0	25.0	76.0	24.4	69.2	20.7
Central	Marysville	54.3	12.4	59.4	15.2	64.8	18.2	72.8	22.7	77.8	25.4	76.2	24.6	71.9	22.2
Central	Sacramento	54.3	12.4	58.1	14.5	63.3	17.4	69.4	20.8	73.2	22.9	72.9	22.7	69.3	20.7
Central	Upper Lake	49.9	9.9	54.8	12.7	59.6	15.3	66.7	19.3	73.8	23.2	72.7	22.6	66.7	19.3
Central, coastal	San Jose	53.1	11.9	56.3	13.5	58.5	14.7	62.7	17.0	66.5	19.2	66.1	18.9	64.2	17.9
Central, coastal	Santa Rosa	51.2	10.7	54.4	12.4	57.6	14.2	63.0	17.2	65.2	18.4	64.4	18.0	63.8	17.7
Michigan, southwestern	Benton Harbor	34.7	1.5	47.1	8.4	57.9	14.4	68.1	20.0	72.7	22.6	71.3	21.8	64.0	17.8
New York:															
Hudson River Valley	Poughkeepsie	37.3	2.9	49.5	9.7	60.7	15.9	69.6	20.9	74.6	23.7	72.4	22.4	64.6	18.1
Western	Rochester	32.3	0.2	45.1	7.3	56.7	13.7	66.9	19.4	71.6	22.0	69.7	20.9	62.4	16.9
Oregon:															
Hood River Valley	Hood River	43.3	6.3	49.9	9.9	56.1	13.4	61.6	16.4	67.4	19.7	66.6	19.2	59.5	15.3
Rogue River Valley	Medford	46.7	8.2	51.6	10.9	57.7	14.3	65.2	18.4	71.8	22.1	70.8	21.6	63.1	17.3
Washington:															
Wenatchee River Valley	Wenatchee	42.8	6.0	51.5	10.8	58.8	14.9	66.2	19.0	73.2	22.9	71.6	22.0	61.6	16.4
Yakima River Valley	Yakima	44.1	6.7	52.5	11.4	59.0	15.0	66.4	19.1	71.4	21.9	69.5	20.8	61.1	16.2

PEAR-GROWING AREAS

Most of the commercial pear production of the United States is restricted to areas where growing conditions are especially favorable. These areas are as follows: (1) Interior valleys of central California, including the smaller tributary valleys and adjacent slopes and foothills; (2) coastal sections of central California; (3) Rogue River Valley of southwestern Oregon; (4) Hood River Valley of north-central Oregon; (5) valleys of central Washington; (6) intermountain areas of Idaho, Utah, and Colorado; (7) central region; (8) northeastern region; and (9) southern region.

Production and Utilization of Pears

The number of pears sold commercially in the United States by State and by Pacific coast area for 1973, 1974, and 1975 is given in table 2. The trends in production and use for 1963 through 1974 are shown in table 3. The pear acreage in the principal growing areas is given in tables 3 to 6. The pear-growing centers in California, Oregon and Washington are shown in figures 1 to 3.

Interior Valleys of Central California

Pear culture in the interior valleys of central California is mainly restricted to a few sections, but commercial orchards are scattered throughout almost the entire area. Approximately half the pear trees in California grow in this area. The principal pear-producing sections here include (1) the bottom lands of the Sacramento River Valley, (2) the foothills east of this valley, (3) the valleys northwest of the lower Sacramento River Valley, and (4) the Clear Lake district of Lake County and the Ukiah district of Mendocino County. All are desirable for the production of the Bartlett variety.

Table 2.—Utilized production of pears by States and Pacific coast, variety composition, 1973-75[1]

State	1973	1974	1975	Pacific coast	1973	1974	1975
	Tons	*Tons*	*Tons*		*Tons*	*Tons*	*Tons*
Connecticut	1,500	1,400	1,900	Washington:			
				Bartlett	123,500	126,400	154,500
New York	12,600	14,000	17,500	Other	63,800	86,900	85,500
Pennsylvania	1,800	3,200	3,400	Total	187,300	213,300	240,000
Michigan	9,500	10,500	15,000	Oregon:			
				Bartlett	73,000	72,000	79,000
				Other	98,000	103,000	93,000
Idaho	1,300	1,050	1,650				
				Total	171,000	175,000	172,000
Colorado	5,510	4,590	6,000				
				California:			
Utah	5,830	3,200	4,100	Bartlett	317,000	297,000	294,000
				Other	10,300	13,900	6,350
Washington	187,300	213,300	240,000				
				Total	327,300	310,900	300,350
Oregon	171,000	175,000	172,000				
				3 States:			
California	327,300	310,900	300,350	Bartlett	513,500	495,400	527,500
				Other	172,100	203,800	184,850
Total United States	723,640	737,140	761,750				
				Total	685,600	699,200	712,350

[1] Taken from *Fruit situation*, Economic Research Service, USDA, TFS-198, March 1976.

Table 3.—Pears: Production and utilization, by States, crop of 1975 (preliminary)[1]

State and variety	Not utilized[2]	Production[3]	Utilization: Fresh[4]	Processed (fresh basis): Canned[5]	Processed (fresh basis): Dried
	Tons	*Tons*	*Tons*	*Tons*	*Tons*
California, all		300,350	([6])	([6])	([6])
Bartlett . .		294,000	66,400	221,900	5,700
Other . . .		6,350	([5])	([5])	
Colorado . . .		6,000	([5])	([5])	
Connecticut .		1,900	1,900		
Idaho		1,650	([5])	([5])	
Michigan . . .		15,000	([5])	([5])	
New York . .	2,500	17,500	([5])	([5])	
Oregon, all . .	3,000	170,000	98,500	([5])	([5])
Bartlett . .		79,000	17,500	61,500	([5])
Other . . .	3,000	91,000	81,000	10,000	
Pennsylvania		3,400	3,400		
Utah	800	4,100	4,100		
Washington, all		219,000	([5])	([5])	([5])
Bartlett . .		133,500	50,700	82,800	
Other . . .		85,500	([5])	([5])	([5])
United States	6,300	738,900	326,900	406,150	5,850

[1] Taken from *Agricultural Statistics* 1976, USDA.

[2] Quantities not harvested for economic reasons and excess cullage of harvested fruit.

[3] Production is the quantity sold or utilized.

[4] Includes "Home use."

[5] Some quantities otherwise processed are included in "Canned" to avoid disclosure of individual operations.

[6] Data not published to avoid disclosure of individual operations, but included in U.S. totals.

Bottom Lands of Sacramento Valley

The bottom lands of the Sacramento Valley constitute one of the most important pear-growing sections of the Pacific slope. Between the cities of Sacramento and Isleton pear culture is the most important fruit industry. Practically all the pear trees in this section are near the river.

The soils devoted to pear culture are largely sedimentary and of recent origin, having been deposited over a layer of peat. In some places the overflow from the river has added to the depth of the soil since the early orchards were established. Levees now prevent the river from overflowing. The dark soil is an open, friable, warm loam. The Bartlett, which is grown almost to the exclusion of other varieties, produces excellent fruit here both for dessert and for canning.

All orchards of this section are equipped for irrigation. Water from the river is easily and cheaply obtained by means of pumps beside the river and pipes through the river levees.

As in most other sections of California where pears are grown, the coldest weather brings frequent frosts but only occasional light freezes. A large part of the pear-producing section lies within the area where summers are moderately hot, although tempered to some extent by cool breezes from San Francisco Bay.

Pears in this section mature early. The first Bartlett shipments from the State usually originate here. The first shipments normally are made early in July, and the fruit moves to eastern markets for approximately 6 weeks. A large part of the late-harvested fruit is canned.

Foothills East of Sacramento Valley

In the foothills east of the Sacramento Valley, about 3,000 acres of pears are grown in Placer and El Dorado Counties. The highest elevation of orchards in this section is about 3,500 feet. The Bartlett is by far the most important variety. The fruit reaches high dessert quality and ships well to market.

Table 4.—Pear acreage in major producing counties of California and total for State[1]

County	Bartletts			Other pears		
	Nonbearing	Bearing	Total	Nonbearing	Bearing	Total
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Lake	1,105	7,550	8,655	20	35	55
Sacramento	255	6,137	6,392	0	98	98
Mendocino	372	4,053	4,425	39	32	71
Solano	452	3,221	3,673	1	2	3
El Dorado	233	2,117	2,350	5	121	126
Santa Clara	150	1,540	1,690	62	355	417
Sonoma	107	1,555	1,662	3	2	5
Yuba	287	1,484	1,771	10	93	103
Other counties	439	8,522	9,661	369	554	923
Total	4,100	36,179	40,279	509	1,292	1,801

[1] Data from California Department of Agriculture for fruit and nut acreage, 1974.

Table 5.—Pear acreage in principal producing areas of Oregon and Washington[1]

Variety	Hood River County, Oregon		Jackson County, Oregon		North-central Washington		Yakima Valley, Washington	
	Nonbearing trees	Bearing trees	Nonbearing trees	Bearing trees	Nonbearing trees	Bearing trees	Nonbearing trees	Bearing trees
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Bartlett	1,120	3,360	100	4,400	1,545	1,623	1,390	7,075
Anjou	1,147	2,952	0	1,900	1,330	2,055	761	1,422
Bosc	118	303	250	1,950	1	9	100	150
Comice	45	35	280	120	0	4	-	-
Other pears	46	117	10	435	31	7	177	150
Total	2,476	6,767	650	9,805	2,907	3,698	2,428	8,797

[1] 1976 estimated pear acreage supplied by county extension agents for various pear districts based on earlier tree censuses.

Table 6.—Pear acreage in principal producing areas of Michigan and New York

Variety	Michigan[1]		New York[2]	
	South-western	West-central	Hudson River Valley	Western
	Acres	*Acres*	*Acres*	*Acres*
Bartlett . .	5,800	2,765	996	2,591
Bosc	233	72	323	432
Clapps Favorite . .	98	58	108	178
Seckel . . .	-	-	24	74
Other pears	366	8	239	20
Total[3] . .	6,496	2,903	1,690	3,295

[1] 1973 Michigan Tree Census.
[2] 1975 New York Crop Reporting Service.
[3] Includes 285 acres of Kieffer pears.

On hillsides or where the soil is not deep, the fruit is usually smaller than from orchards on the deep soils of the river bottom. Pears from lower elevations ripen about the same time as the river pears of the same varieties. The harvest in the higher orchards is considerably later; therefore, fruit from these orchards has an advantage in arriving on the market after peak shipments are past. The Bosc, Winter Nelis, and other winter pears are minor commercial varieties in this section, grown mainly as pollinizers for the Bartlett.

Most of the trees on the poorer soils in this section are not large, and the yield is not as heavy as on the deep bottom lands. Because of the late ripening of the fruit, its high shipping and dessert qualities, and excellent appearance, much of the output is shipped fresh, but some of it is canned. All the orchards are irrigated.

Much of the soil in this section is derived from the weathering of granite bedrock and is open, easily worked, fertile, and well drained, but it is low in organic matter. It is several feet deep in some places; in others it is shallow, and outcroppings of granite are common. In the Placerville-Camino district of El Dorado County, pears are planted mostly on Aiken clay loam, a residual soil from disintegrating schist rocks. It is red, friable, and of good depth and contains a moderate amount of organic matter. The summers are generally hot but somewhat shorter than along the Sacramento River or in the districts lower in the foothills.

Valleys Northwest of Lower Sacramento Valley

A third section of the interior valleys of central California includes the district near Fairfield and the Vaca Valley, which is northwest of the lower Sacramento River Valley; both are in Solano County. Around Fairfield the summer temperatures are more like those of the coastal section. Little water is available for irrigation. The Bartlett is the principal variety, and most of the fruit is shipped fresh.

In the Vaca Valley the summers are hot and advance rapidly. The soil is a very deep, fertile, friable loam. The trees are thrifty, but due to lack of moisture they do not grow rapidly and the tonnage of fruit produced is only moderate. The slow growth provides unfavorable conditions for fire blight development. Some of the pear orchards are old. New plantings are few because most of the available orchardland in this valley has been planted.

Lake and Mendocino Counties

The fourth section of pear production in the interior valleys of central California includes the Clear Lake district around Kelseyville and Upper Lake, both in Lake County, and the Ukiah district in Mendocino County. In some places the soil is a deep and easily tilled loam, but generally it is a rather heavy black clay that generally slopes to the level of the lake. It is very fertile but should be worked only at the proper time. All the orchards are irrigated. The water is obtained largely from wells.

The Bartlett is grown practically to the exclusion of other varieties. Trees grow well and bear regularly. The fruit is large, of good quality, and an attractive color. It ripens later than in the principal pear sections of the Sacramento Valley. Consequently, it reaches the market after the heavy shipments from those sections have been sold. The fruit attains excellent shipping quality because of the high temperatures. Most of the crop is shipped fresh or sent to canneries. Lake County is the major fresh-shipment district in the State. Approximately one-half of its production moves into fresh-fruit channels.

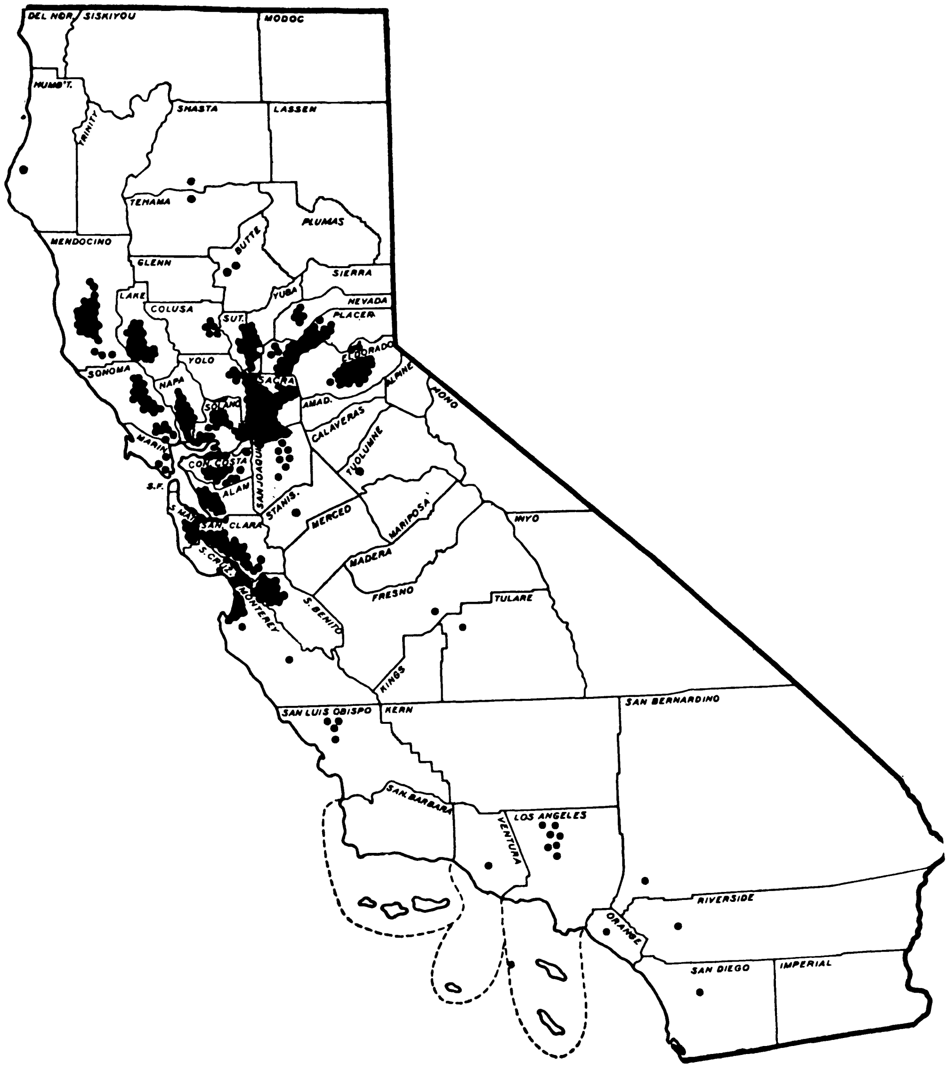

Figure 1.—Distribution of pear growing in California; each dot represents 100 acres of pears.

Coastal Sections of Central California

The principal pear-growing sections between the Coast Ranges and the Pacific Ocean in California are the low coastal plains adjoining San Francisco Bay in Santa Clara, Santa Benito, Alameda, and Contra Costa Counties; the Napa Valley in Napa County; and the Sonoma Valley in Sonoma County. The temperatures are much lower than in the interior valleys because of the ocean breezes. As a result, fire blight is less likely to develop and the fruit ripens later than usual. The Bartlett is of less desirable quality for distant shipping than in sections where there are a few weeks of high temperatures before harvest.

This area is one of the oldest centers of commercial pear culture in California. A few of the orchards planted in the middle of the 19th century are still cultivated, though many of them, as well as younger acreages, have succumbed to the rapid encroachment of residential development.

More varieties are grown commercially in this area than in other parts of California. Bartlett is predominant, but there are substantial acreages of Hardy, Anjou, Bosc, Winter Nelis, and Comice. Bartlett is grown ostly for canning, but the other varieties are shipped fresh.

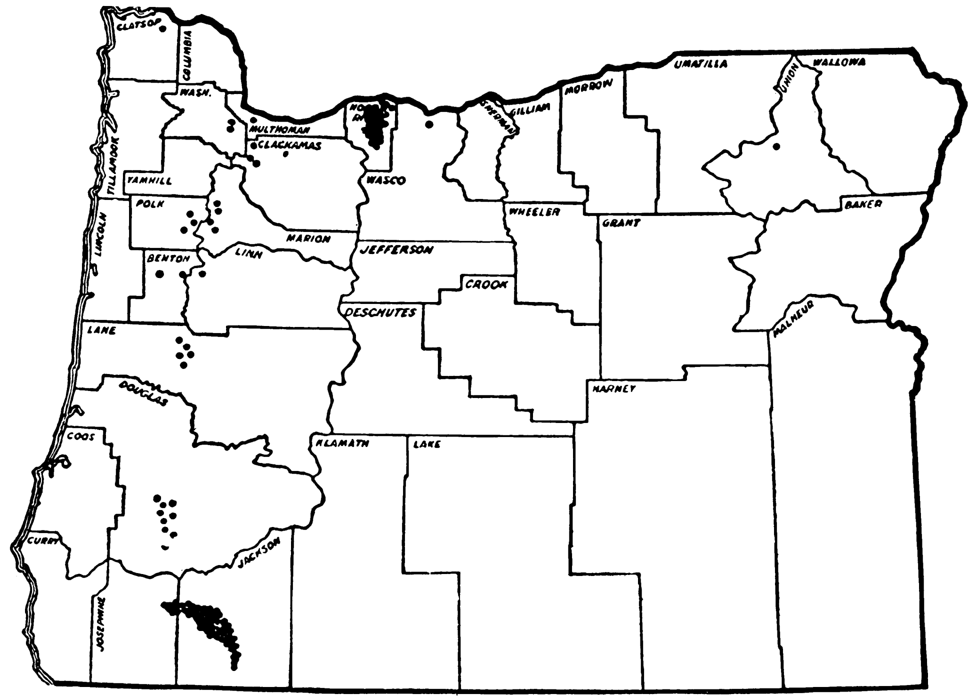

Figure 2.—Distribution of pear growing in Oregon; each dot represents 100 acres of pears.

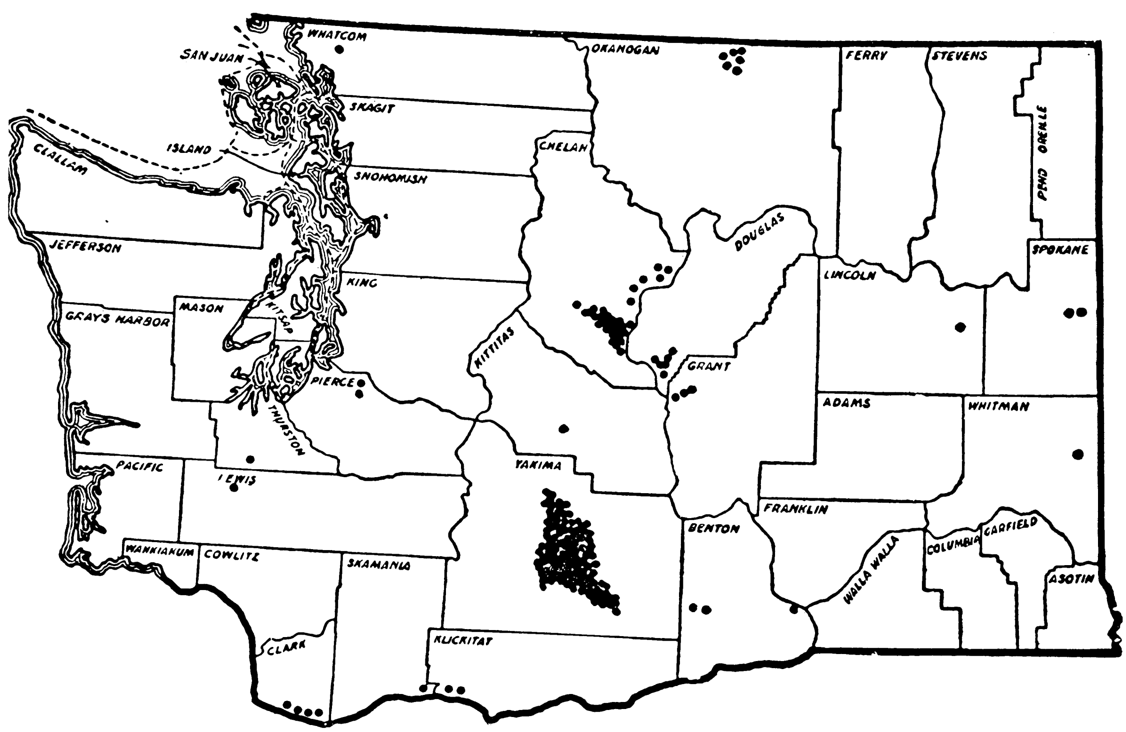

Figure 3.—Distribution of pear growing in Washington; each dot represents 100 acres of pears.

Many of the pear orchards near San Francisco Bay are at a low elevation. The soil is a dark, moderately heavy clay, which is fertile but sticky when wet and hard when dry. Farther back from the bay and at higher elevations the soil becomes more loamy and open and is well adapted to the culture of other deciduous fruits and nuts. Occasional pear orchards have also been planted on this more loamy land, and they generally have good tree growth and production. Practically all the orchards of this section are irrigated. Santa Clara County ranked third in total pear acreage in California in 1962 with 6,000 acres.

Throughout this coastal area, as well as in the more southern sections of California, the Bartlett pear tends to lose its characteristic long shape. Under extreme conditions the radial diameter of the fruit almost equals its length, and the fruit is less desirable for canning. This condition constitutes a serious problem in coastal sections where the crop is largely used for canning. Fruit from the more southerly sections averages shortest in proportion to diameter; the ratios vary from about 1.2 to 1 in central California to about 1.5 to 1 in Yakima, Wash.

Rogue River Valley of Oregon

The principal pear plantings in western Oregon are in the Rogue River Valley of Jackson County. Limited plantings are in the Umpqua and Willamette River Valleys. The Rogue River Valley area, lying west of the center of the State and almost touching the California line, has 10,500 acres of pears. It ranges from 1,874 feet above sea level near Ashland on the south to 935 feet at Grants Pass on the north and is almost entirely surrounded by mountains. Medford is the principal shipping point. Large plantings were made early in this century, although about half of the present acreage has been planted since water for irrigation was made available between 1917 and 1920.

Freezing temperatures occur throughout the Rogue River Valley in winter. Spring frosts are the most limiting production problem, particularly in the valley floor with poorer air drainage than the foothills. About 6,500 acres are protected by fuel oil heaters; 2,000 acres are protected by an overhead irrigation sprinkler system developed locally during the past 12 years. The system provides 0.15 to 0.17 inch of precipitation per hour during critical temperatures.

Pear trees grow and produce best on the deeper volcanic clay as well as the deep sandy loam soils along Bear Creek and the Rogue River. Although the soil is fertile, much of it is underlain by a stratum of hardpan at a depth varying from a few inches in some of the uplands to several feet in the bottom lands. In parts of the Rogue River Valley, the water table is high and the soil is heavy, thus drainage is required. Extensive early apple plantings have gradually been replaced with pear trees, which will withstand these conditions more successfully.

The Bartlett, Anjou, Bosc, and Comice are the varieties most extensively planted. About 37 percent of the acreage is the Bartlett variety with about one-half shipped fresh and one-half canned. They have high dessert quality, which can be retained for up to 8 weeks of storage. A few Seckel, Eldorado, Packham, and red varieties are also produced successfully.

The area is best known for its high-quality winter varieties. A good quality, blight resistant Anjou has good market acceptance, but acreage is declining slowly due to lower yields than the Anjou pear districts to the north (fig. 4). Bosc acreage is increasing due to excellent eating quality, classical uniform russetting, and good yields. The Comice acreage is also increasing due to the extensive gift pack industry in Medford. The climate and soils produce superior quality, sweet, juicy fruit, which is gaining sales in the commercial 46-pound carton as well as gift packs sold primarily in the Thanksgiving-to-Christmas season.

In the Umpqua and Willamette River Valleys, pears are grown commercially, but they are not among the most important fruits. Summer temperatures are lower than in the Rogue River Valley and not warm enough for the best development of most pear varieties. Because of the lower temperatures, there is almost no loss from blight. Winter injury has at times been serious in the Willamette River Valley, causing the loss of many orchards.

Hood River Valley of Oregon

The Hood River Valley, about 120 miles from the coast and at the extreme northern boundary of Oregon, is an important pear-growing area. The Bartlett and Anjou are the principal varieties grown (table 5). The Bartlett is used mainly for canning, with some fresh-fruit shipment.

The soils of this area vary considerably in depth

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Figure 4.—Typical Anjou pear orchard on adobe soil, Medford, Rogue River Valley, Oreg.

and texture, but not sufficiently to restrict the planting to given soil types. Pear orchards are scattered throughout the fruitgrowing part of the valley. Most of the surface soils are sandy or silty loam, very open, and in many places rather shallow. Water passes through these soils rapidly. The subsoils are composed of about the same materials as the upper soils in many places. Some of the subsoils are very open, permitting good or sometimes excessive drainage; others are so compact that downward movement of water through them is slow.

The rainfall during the summer is light, and practically all orchards are irrigated. With the very open and well-drained soils in one locality and compact subsoils in another, careful observation and caution are necessary in adopting a successful irrigation program. Although the roots of pear trees can stand excessive soil moisture better than the roots of many other fruit trees, they will not thrive in waterlogged soils. Therefore, where a hard substratum is too near the surface, care in drainage is necessary to prevent an accumulation of seepage water from higher levels.

As the soil has a high sand and silt content and the surface layer suited to root growth is shallow in some places, the humus content needs to be increased and maintained. Cover crops, either cultivated plants or native vegetation, are grown for this purpose in most orchards.

Winter injury constitutes a greater hazard to pear production in this area than in most of the other important pear areas of the Pacific coast. Winters are generally mild, but occasional severe cold weather when the trees are not thoroughly hardened has resulted in serious damage, particularly to young trees. Fire blight has not been serious in the Hood River Valley.

Valleys of Central Washington

Two irrigated sections, one the Yakima River Valley and the other along the Columbia and Wenatchee Rivers centering around Wenatchee, are the most important pear-producing areas of Washington. Pear orchards are scattered throughout these large fruit-growing belts. In the older orchards pears and apples were often interplanted. In both sections the soil is generally deep, fertile, and well suited to pear growing. As the rainfall is very sparse and occurs during the winter, all orchards are irrigated. Fire blight, although troublesome in some years, is not so severe as in the Rogue River Valley of Oregon and the interior-valley sections of California. For acreages and varieties of pears grown, see table 5.

In both the Yakima and Wenatchee sections the Bartlett attains good size, shape, and quality for canning. The fruit reaches the extreme length in proportion to width in these northern sections, a shape very popular for canning. With abundant cold-storage facilities in the area, much of the Bartlett crop is held in cold storage and sent to canneries when they want it. Some of it is placed on the fresh-fruit market after the California shipments are over.

Intermountain Areas of Idaho, Utah, and Colorado

Pears are a relatively minor crop in Idaho, Utah, and Colorado. Production is mainly restricted to the semiarid valleys and foothills where other deciduous fruits are grown. In Idaho, pear orchards (about 500 acres, mostly Bartlett) are scattered throughout the southwestern part of the State in the same general areas where apples are produced. In Utah, most of the pears (about 1,200 acres, mostly Bartlett) are produced in Utah County about 75 miles south of Salt Lake City in the vicinity of Provo. Orchards are located on canyon deltas above the floor of the valley. Commercial pear production in Colorado is limited entirely to the western slope in Mesa and Delta Counties.

Pears in the intermountain areas require irrigation. Climate and growing conditions are similar to those in the lower Yakima Valley of Washington. Bartlett and Anjou are the principal varieties grown.

Central Region

Michigan, the leading pear-producing State of the central region, ranks fourth in production, exceeded only by California, Oregon, and Washington. The pear industry of this State centers in three southwestern counties—Berrien, Van Buren, and Allegan—located along the eastern shore of Lake Michigan. The moderating effect of the lake reduces the dangers of spring frost, and the relatively cool weather during the early growing season aids in the control of fire blight. Bartlett is the principal variety (table 6).

Pear production in Illinois is scattered through several counties in the southern third of the State but centers in Marion County. Other principal pear-producing States in the central region include Ohio and Indiana. In the former, State commercial production is centered in the counties bordering on the southern shore of Lake Erie. Pear acreage in Indiana is widely scattered, but most of it is centered in Posey and Gibson Counties in the extreme southwestern corner of the State.

Northeastern Region

New England climate is generally regarded as too severe for pear production, except for relatively small acreage in the Connecticut River Valley. New York, however, produces substantial quantities of pears. The production areas of this State are centered in western New York and the Hudson River Valley. The leading pear-producing counties of western New York are located on the southern shore of Lake Ontario. Climate and soil conditions in this area are similar to those in southwestern Michigan. Pear acreages in the Hudson River Valley are located south of Albany and centered in Columbia, Orange, Ulster, and Dutchess Counties. In New York the Bartlett constitutes nearly 70 percent of the pear acreage (table 6).

Pear production in Pennsylvania is widely scattered and the crop is used largely to supply local demands. Chester and Lancaster Counties and the southeastern part of the State are the most important areas.

Southern Region

With few exceptions high-quality European-type pears cannot be successfully grown in the South because of susceptibility to fire blight. Pears of the oriental type are far more tolerant, but their fruit quality is low and they are best suited for cooking and preserving. Several varieties have been developed with improved quality and fire blight resistance. Most of these are hybrids between *Pyrus* *communis* and oriental species, but some have been derived entirely from *P. communis* varieties. Also, varieties have been developed that require less winter cold to break dormancy and are consequently better adapted to the warmer areas of the South. Such pear-breeding programs are making it possible to produce better quality pears throughout the Southern States.

Relatively few areas in the South produce pears commercially. Most production is primarily for home consumption, with a limited outlet for local markets. Pears are grown in widely scattered areas throughout the Southern States. If blight-resistant varieties are planted in well-drained soil on a site with good air drainage, pears can be satisfactorily produced in many areas of this region.

Kieffer is perhaps the most widely planted pear in the South. It is moderately resistant to fire blight but is relatively low in quality. Maxine and Waite are superior in quality to Kieffer and somewhat more resistant to fire blight. They are well adapted to southern conditions. Baldwin and Orient have a lower chilling requirement than other varieties and can be grown in the lower South where mild winter temperatures are insufficient to break dormancy.

SITES AND SOILS FOR PEAR ORCHARDS

From the standpoint of air drainage for frost protection, the slopes of rolling lands are preferable for pears; but for the purpose of crop diversification, these places are often planted to fruits that blossom earlier than pears, such as apricots, almonds, plums, and peaches, and are therefore more susceptible to frost injury at blossomtime. Consequently, pears are frequently planted at the lower sites, where artificial frost-prevention practices are sometimes necessary. Because of better air drainage, trees located on sloping land are less susceptible to fire blight, and the fruit is less likely to develop serious russeting.

The best soil for pears is deep, medium textured, well drained, fertile, and easily worked. Although pears will thrive best on such a soil, they will do reasonably well where the soil has a high water table, is poorly aerated, or is too heavy in texture for most other deciduous fruits. Pear trees seem to grow well on the heavy soil of the Santa Clara Valley, Calif., and the heavy adobe in the Medford, Oreg., district. If grown on tolerant rootstock, they can withstand unfavorable soil-moisture conditions. Trees growing behind the levee of the Sacramento River have each winter a water table within 2 feet of the surface and occasionally have stood in water for many days. This is not an ideal situation, but it does illustrate the tolerance of the pear toward unfavorable conditions.

ROOTSTOCKS FOR PEARS

Pear varieties, like other orchard fruits, do not reproduce true from seed and thus must be budded or grafted to seedling or clonal rootstocks. Perhaps no other phase of pear culture is more important than the proper choice of a rootstock. Extensive studies have been made to determine the most suitable stocks for specific climates, soil conditions, disease resistance, growth control, and fruit quality. Rootstocks and their specific traits are given in table 7. Rootstocks assumed added significance when it was shown that the incidence and severity of pear decline in the Western United States depended directly upon the genetics of the rootstock used. Pear decline is now known to be caused by a mycoplasma, which, when transmitted to the tree by psylla insects, moves down the living bark to the graft union where it causes tissue death (and girdling) of trees on susceptible roots. The most susceptible stocks are *Pyrus pyrifolia* (Burm.) Nak. (Japanese or Serotina pear) and *P. ussuriensis* Max. (Chinese pear). These should not be used as rootstocks for domestic (European) pear.

Until about World War I, most pear trees were propagated on French seedlings. The seeds were obtained from cider mills of continental Europe and were derived from native trees of *Pyrus communis*. During and immediately after World War I, French seeds were not generally available and nurserymen used oriental seedlings (*P. pyrifolia* and *P. ussuriensis*) almost exclusively. The greater resistance of these stocks to fire blight was an added incentive in bringing about their widespread use. These stocks proved highly desirable for the nurseryman. They were easy to propagate and made a thrifty tree in the nursery. Under good soil and moisture conditions, trees propagated on these stocks grew well in the orchard. However, fruit from these trees frequently exhibited black end, rendering it virtually worthless. Because of this, many orchards propagated on these stocks were eliminated.

About 1925, most propagators returned to the use of French seedlings. In most cases seeds were obtained from Western canneries and came from open-pollinated Bartlett, although Winter Nelis seeds were used to some extent. Thus, 1925 marks the beginning of the use of domestic seedlings of *P. communis*, generally referred to as domestic French. Stocks derived from this source, although susceptible to fire blight, proved satisfactory under a wide variety of conditions and, since 1930, have been the predominant stock used in the Pacific Coast States.

Other stocks used include quince (*Cydonia oblonga* Mill.), *P. calleryana* Decne., *P. betulaefolia* Bunge, and *P. communis* types, including Winter Nelis seedling, self-rooted Old Home, and Old Home x Farmingdale (OH x F). The interest in the Chinese species and blight-resistant Old Home and OH x F started with F. C. Reimer at the Southern Oregon Experiment Station. In about 1915, he initiated work on blight-resistant rootstocks and trunkstocks, which lasted more than 40 years. Not only did he collect all available domestic sources of blight resistance, but he also made two trips to China, Korea, and Japan to collect native wild species. *P. calleryana* was naturally blight resistant, but *P. betulaefolia* was not; however, Reimer selected four seedling clones, which are blight resistant and produce resistant seedlings.

Much of Reimer's material formed the basis for new studies started in 1960 to find decline-resistant stocks. *P. calleryana* and seedlings of Bartlett and Nelis are nominally tolerant of decline, whereas clonal East Malling Quince A (M Quince A), Lepage Series C Provence Quince (Provence Quince C), Old Home, and OH x F are resistant. *P. betulaefolia* seedling stock are completely resistant to decline and are the most vigorous of all stocks tested. Imported French seedlings and *P. caucasica* Fed. from Eastern Europe are more susceptible to decline than domestic seedlings.

Factors other than blight and decline also may influence choice of a rootstock. Trees grafted on quince, *P. calleryana*, or *P. betulaefolia*, are not as hardy as those grafted on *P. communis* types and find their greatest use in the mild areas of Oregon, California, and the Southern States. Most cultivars are not compatible with quince and need a compatible interstem. Both Old Home and Hardy can be used, but those with Old Home interstem have been more productive. Comice and Anjou may be grafted directly to quince, as can one strain of Bartlett (called Swiss Compatible). Recent work with *P. betulaefolia* indicates that it does not cause hard end as earlier reported. However, it should not be used with Anjou because the extreme vigor and light cropping tendency result in cork spot of the fruit. *P. pyrifolia* (that is, Serotina, Japanese Sand Pear) and *P. ussuriensis* should not be used because they are susceptible to pear decline and show a high incidence of hard end. Old Home (scion rooted) results in a fine healthy tree but is slow bearing compared with several selected OH x F clones. High-yielding clones of OH x F, which are resistant to blight and decline, have been selected and are now being propagated. Some clones are low enough in vigor to result in a semidwarf tree, while others are even more vigorous than Old Home. *P. calleryana* and *P. betulaefolia* are the best adapted to wet, poorly drained soils. Quince can be grown on clay soils if surface and internal drainage are good, but should be planted shallow in furrows rather than glazed holes dug with an auger. Table 7 indicates the general traits of the common rootstocks used in the United States.

SOIL MANAGEMENT AND COVER CROPS

Cultivation

Cultivation is often practiced in commercial pear orchards to remove noxious weeds and weed competition; to facilitate subsequent orchard operations such as irrigation, spraying, brush removal, and harvesting; to incorporate cover crops and manures; to prepare the soil as a seedbed for cover crops; and to conserve moisture.

The most common practice is to disk under the cover crop, either volunteer or planted, that has grown during the fall, winter, and spring. In irrigated areas, the cultivation is performed in advance of the first irrigation. During the remainder of the season the frequency of cultivation will depend on the method of irrigation and the amount of water available. In central Washington where irrigation water is

Table 7.—Important characteristics of pear rootstocks

Rootstock	Vigor	Soil adaptability	Winter hardiness	Pear root aphid	Root sprouting	Tolerance to pear decline	Resistance to fire blight
Pyrus communis types:							
Domestic seedling .	Moderate	Wide range, moisture, and texture	Hardy	Susceptible	High	Good	Low.
Imported French . . .	–do–	–do–	–do–	–do–	–do–	Fair	Low.
Old Home clone . . .	High	–do–	–do–	–do–	–do–	Very high	Very high.
OH x F clones	Low-high	–do–	–do–	–do–	Variable	–do–	High.
Quince	Low	Dry, non-calcareous	Not hardy	Resistant	High	High	Low.
P. calleryana	Moderate	Wide range except high pH	Slightly hardy	–do–	Low	Good	High.
P. betulaefolia	Very high	–do–	Moderately hardy	Moderately resistant	–do–	Very high	Very high.
P. pyrifolia	Moderate	Poor in wet soils	–do–	Variable	–do–	Low	Moderate.
P. ussuriensis	–do–	–do–	Hardy	Moderately resistant	–do–	–do–	Very high.

plentiful, no further cultivation is generally practiced until after harvest. The cover growth occurring during the summer is usually mowed or "floated down" in late summer to facilitate harvest operations. In the Medford district of Oregon and certain areas of California, cultivation is often performed between each irrigation, and thus the soil is kept relatively free of vegetation during the growing season.

Cover Crops

A good cover crop helps to maintain organic matter and to prevent erosion; it improves the physical texture of the soil and aids in water penetration. During the fall, winter, and early spring the growing of some cover crops to be incorporated in the soil is an excellent practice. The cover may be a volunteer crop of weeds or grass, or preferably one that has been planted. The choice of a cover crop should be determined by such environmental factors as soil, water supply, and temperature. Among those most commonly used are annual legumes (yellow sweetclover, common vetch, and purple vetch), mustards, and cereals (rye, barley, and oats). These are generally planted from the middle of September to the middle of October in order to be established before cold weather. In irrigated areas an irrigation is required after seeding to induce germination.

Permanent Sod

In some sections pear orchards have been successfully handled in permanent sod without cultivation. In the central Washington districts fescuegrass is the preferred cover for this purpose. Permanent sod is particularly suited where the sprinkler method of irrigation is used. Sod reduces runoff and increases water percolation. Most covers require mowing at least twice a year, and it is necessary to have sufficient water available for both trees and cover crops.

Legume covers such as alfalfa are not preferred in most pear sections. The control of insects is made more difficult, because legumes are good host plants for the tarnished plant bug (*Lygus lineolaris* (Palisot de Beauvois)), various species of mites, and other insects harmful to pears. Furthermore, the added nitrogen obtained from legumes makes it more difficult to control the desired level of this element. Excessive vigor increases the difficulty in controlling fire blight. Also, in the northern fruit areas a high nitrogen level in the fall increases the susceptibility of the trees to low temperatures, which may occur in late fall or early winter.

FERTILIZATION

In many pear areas nitrogen is the only element needed for proper nutrition of pear trees. The amount required to maintain satisfactory growth and production will vary with the soil type and method of culture. Mature orchards usually require from 75 to 150 pounds of actual nitrogen per acre. It should be applied in either late fall or early spring.

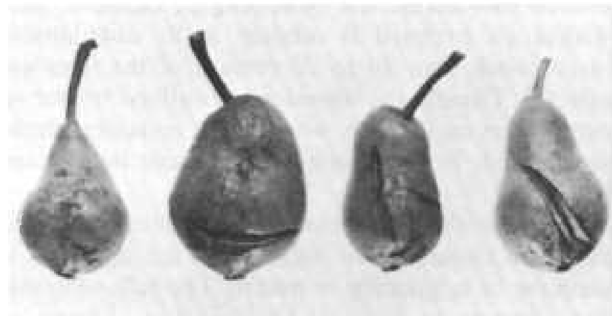
All fertilizers containing nitrogen affect the acidity of the soil. Since slightly acid soils are preferable for pears, all alkaline soils or soils irrigated with hard water, which makes the soil alkaline, should be fertilized with ammonium sulfate. Soils already acid should be fertilized with materials having the least effect on soil pH. These materials include ammonium nitrate, urea, and anhydrous ammonia.

In some western soils, particularly if slightly alkaline, zinc is not available in sufficient amounts to meet the needs of the trees. Zinc deficiency causes the condition known as "little leaf" or "rosette." Leaves are small, very narrow, light colored, and tend to develop in small clusters or "rosettes." Affected leaves also lack the normal green, particularly between the veins. This interveinal chlorosis of leaves on limbs and branches exhibiting little leaf or rosette is positive evidence of zinc deficiency. Zinc deficiency in an orchard can be largely corrected by spraying the trees with zinc sulfate solution just before the buds open in the spring. Zinc applied to the soil is generally unavailable to the trees, because it is largely tied up or "fixed" in the few inches of surface soil.

Zinc deficiency of pears is most common in central Washington, although it has been observed in some orchards in nearly all the major pear areas of the Western States. In California zinc deficiency is most likely to occur in the delta area of the Sacramento River.

In some orchards boron deficiency may also be a problem, particularly in north-central Washington. Boron deficiency may be expressed in several forms. The most common malformity is cork development in the fruit. If the deficiency becomes acute early in the season, a rough scabby or russeted skin will develop, and the fruit will generally crack without showing noticeable cork (fig. 5). If the boron shortage occurs relatively late in the season, well-defined pitting will develop (fig. 6). Associated with these pits are corky areas extending rather deeply into the flesh of the fruit. A diagnosis of the deficiency is confirmed by boron analysis. Mature fruits should contain 10 parts per million (p/m) or more boron and young fruits over 20 p/m.

"Blossom blast" is another form of boron defi-



BN-29824

Figure 5.—Young pear fruits exhibiting early season symptoms of boron deficiency.

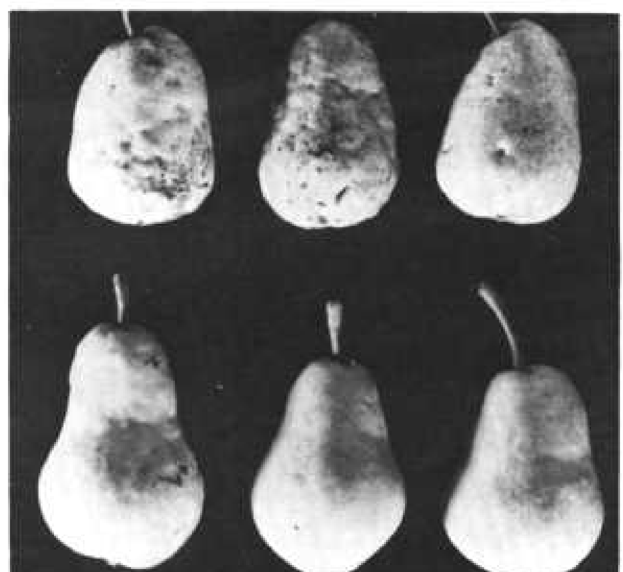


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Figure 6.—Pitting of Bartlett pears caused by boron deficiency (top row); normal fruits (below).

ciency that sometimes occurs in Washington orchards. Typical symptoms are shown in figure 7. Generally the blossoms wilt and die, but the leaves remain normal. The withered blossoms fail to absciss and frequently persist until the following year. With the more severe forms, leaves also die and the limb may or may not put out new buds within a few weeks after the blast occurs. If it fails to do so, the branch dies before the next season. Blossom blast within an orchard is random in its distribution; rarely more than 10 to 20 percent of the trees are affected. Usually the disorder is confined to one or two leaders on the tree, whereas the remaining limbs are normal. Fruit set is greatly reduced on affected limbs.

The general characteristics and conditions associated with blossom blast suggest that the deficiency is incipient or temporary in nature. The following evidence tends to support this premise: Tissues of affected trees have a relatively low boron content early in the season followed by a level of boron equal to that in trees which do not develop the trouble; fruits borne on affected limbs fail to develop deficiency symptoms in the form of fruit pitting later in the season; soil applications of boron fail to correct the disorder effectively; and blossom blast occurs chiefly on heavy soils in seasons unfavorable for early root growth.

BN-29826

Figure 7.—Bartlett pear blossoms exhibiting typical symptoms of blossom blast. Note persistence of dead blossoms.

It has been shown that the boron requirement of pear trees suffering from all types of boron deficiency can be effectively supplied in the form of boron sprays, preferably applied in late summer or early fall. Early spring applications may fail to become effective before blossom blast is initiated. Soil applications are generally effective in preventing fruit symptoms, but have no advantage over a yearly spray application.

When soil pH values become greater than 7, deficiencies of iron and manganese may develop. The most common of these high pH problems is iron deficiency, or lime-induced chlorosis. It occurs when alkaline water is used for irrigation or when water containing alkaline salts rises to the surface in a seepage area. Leaves lacking iron are yellow, with a fine network of green veins. In severe cases the leaf dies around the edges. Although chlorosis is sometimes difficult to correct, the most effective means is soil injection of an iron chelate solution. Iron chelate sprays applied early in the growing season are generally less effective than soil injections.

Manganese deficiency is rather common in several of the pear-growing areas of the Pacific Coast States. Symptoms are found on the leaves only, and the older leaves are affected more than the young ones. The chlorosis is yellow or golden in contrast to the creamy white of zinc deficiency. Leaf size is not affected as in the case of zinc. The chlorosis pattern is interveinal; the leaf tissue adjacent to the major veins remains green, but the tissue between the veins turns yellow. The diagnosis is verified by leaf analysis. Values less than 25 p/m of manganese are low and less than 15 p/m indicate acute deficiency.

Manganese deficiency is easily corrected with manganese sulfate sprays, but there are few, if any, instances where such a treatment is necessary. The use of ammonium sulfate as a nitrogen fertilizer provides all the control necessary by making the soil sufficiently acid to release enough manganese to meet the requirement of the trees.

Only a few instances of potassium deficiency have been recorded throughout the pear-growing areas of the Pacific Coast States. Potassium diminishes with depth, and where land has been leveled to facilitate irrigation, some deficiency may occur. Potassium deficiency is also prevalent in a few foothill orchards of California, where the soil is unusually light and shallow. In certain areas of New York and Michigan potassium deficiency frequently occurs, particularly when young pear plantings are set in old orchard sites.

An acute shortage of this element results in marginal leaf scorch, which appears first on older leaves of spurs and shoots. Milder symptoms involve a rolling of the leaf blade upward and inward, giving the leaf a "cigarshaped" appearance. When potassium is deficient, fruit size is reduced and maturity is accelerated. The deficiency can be positively diagnosed by leaf analysis and can be corrected by liberal applications of potassium salts to the soil or the use of a mixed fertilizer containing adequate quantities of this element.

Magnesium deficiency is rather common in parts of the South and may be a factor in certain areas of New York and Michigan. The symptoms of magnesium deficiency are yellowing of the leaf at the margins and browning of the margins as the leaf ages. Some varieties show distinct interveinal chlorosis and interveinal browning. The leaves are generally small, and in severe cases partial defoliation occurs before harvest. Symptoms rarely develop before midsummer and are not prominent until late summer or fall. They are usually much more pronounced on spur leaves, though the deficiency can frequently be observed on the basal leaves of terminal shoots. In severe cases premature defoliation occurs and fruit size is reduced. Dolomitic limestone is generally applied as a corrective measure.

IRRIGATION

Supplying water to the trees in irrigated areas is one of the most important operations in successful pear growing. If the orchard becomes so dry that the rate of fruit growth is reduced during the growing season, final size of the fruit and total tonnage will be reduced in proportion to the length and severity of the water shortage. On the other hand, use of excessive water may lead to difficulty. Poorly drained soils may become waterlogged and injure roots. Because water must be pumped and is expensive in many pear districts, it should not be wasted.

Four methods of applying water are used in pear orchards. In California on fairly level land of medium or heavier texture, the flooding or basin method is largely used. Small dikes are erected as necessary to enclose an area of approximately level land. They should be small enough so that water can be applied rapidly from the available supply. These basins are then filled with water sufficient to restore soil moisture to the desired depth. Generally 6 to 8 acre-inches will be supplied per irrigation. This method wets all the soil uniformly.

On moderately sloping land the rill or furrow method is generally used. Four or five furrows, equally spaced in the center between each tree row, are opened. Water from a head ditch or pipeline is run into these furrows at such a rate that it will be taken into the soil within the length of the furrow. Furrows must have only a moderate slope—generally 4 to 6 inches per 100 feet—to avoid erosion and to obtain even, moderately uniform infiltration. In light-textured soils often the whole root zone will not be wet from furrows. In the tree row, particularly, an area of dry soil remains. Also, with furrows it is difficult to supply a uniform quantity of water along the length of the furrow. Frequently excess water may accumulate at the lower end of the furrow, or sometimes insufficient water may reach the lower end. Skill and care are essential for uniform application of water from furrows.

A third method of application is with sprinklers. Light-weight aluminum pipe, with rapid coupling devices, is used in many pear orchards, especially where the soil is fairly steep or so open that water enters it rapidly. By sprinkling, all the soil is wet and response of the trees has been very good, particularly on sites where uniform distribution of water by furrows or basins is difficult. Equipment for sprinkler irrigation is expensive, but improved water distribution and tree response are justifying its use in many orchards.

The fourth method is trickle irrigation in which water is emitted through small, regulated orifices in plastic pipe. This method is useful when the water supply is limited.

The amount of water required by pear trees will vary with the temperature and humidity and with the size and leaf area of the trees. Only a small amount of water is used before the bloom season, since there is little foliage on the trees. Use of water increases as the foliage develops and as the days become hotter and generally drier.

In the interior valleys of the Pacific Coast States, vigorous mature pear trees will use from 5 to 6 acre-inches of water per month in July and August and a little less in June and September. Since some water is lost by evaporation and from other causes when irrigating, about 7 acre-inches per month may need to be applied in July and August. On deep soils of good water-holding capacity, this amount can be applied in one irrigation, and irrigating monthly will be satisfactory. On shallow or coarse-textured soils, more frequent and lighter watering should be practiced.

PRUNING

Pruning is necessary to obtain satisfactory yields of good-quality fruit. The growth conditions and the various characteristics of different varieties all determine the type and degree of pruning in a given situation. In general, the greater the amount of pruning the larger the fruit and the less the total yield. Both canners and shippers prefer fruit 2-3/8 inches in diameter and larger. To produce fruit of adequate size and quality, moderate pruning is required, but extreme pruning should be avoided because of its adverse effect on yield.

Pruning Young Trees

The pruning of young trees is intended to develop tree structure. By skillfully selecting certain branches for the framework and by removing others, the pruner builds the foundation for long-lived trees that is strong enough to carry heavy crops. With young trees, developing structure is the first concern; producing fruit is secondary. Thus, pruning young trees may more properly be referred to as training. During the training process the aim should be to develop a sturdy tree capable of producing large crops of quality fruit.

At the time of planting, young trees should be cut back to 24 to 30 inches from the ground to balance the loss of roots removed in digging the trees from the nursery and also to form a relatively low head, which is desirable in developing a profitable tree. During the dormant period after the first growing season, three branches should be selected and headed to a length of 24 to 30 inches in order to force secondary branches. All others should be removed. The selected branches may emnate at about the same point on the trunk, or they may be selected around the trunk at a distance of 6 to 8 inches apart. The angles of the framework branches should be as wide as possible for added strength, but this feature is not so important as with apples. Pear limbs rarely break under the stress of a heavy load.

At the second dormant pruning, the secondary framework branches should be selected. Generally each of the three branches forming the original framework will give rise to several shoots, from which four to six secondary scaffolds are selected. All other vigorous growth is removed. Each of these branches should be headed at the point where a third set of branches is desired.

Beginning with the third dormant pruning and continuing until the framework is complete, each of the four to six secondary branches selected at the second pruning is headed at the point where the next whorl of branches is desired. The other shoots are thinned out and left unheaded. Further heading is usually unnecessary. If the trees have grown well, the framework should be established. Until the tree comes into bearing, only small branches should be moderately thinned. The lighter the pruning at this point the larger the tree and the sooner it will fruit.

Pruning Bearing Trees

After a tree begins to bear fruit, pruning is necessary to maintain a balance between fruit production and vegetative growth. Although fruit color is not a factor, branches and shoots should be thinned out sufficiently to allow adequate sunlight in order to maintain vigor throughout the bearing area of the tree. Excessive heading back of shoots is likely to result in too much vegetative growth. Both heading and spacing are usually required to maintain a proper balance. If sufficient wood for spur replacement is obtained and if trees are not pruned so severely as to limit the crop, it makes little difference whether the desired results are obtained by thinning, heading, or a combination of both. A well-pruned Bartlett tree is shown in figure 8, *B*. Some moderate heading of vigorous shoots was performed, but thinning and spacing of excessive shoot growth constituted the bulk of the pruning.

Anjou, with its characteristically light set of fruit and consequent large leaf area per fruit, frequently produces fruit larger than that preferred by the trade. The ideal way to produce smaller fruit would be to increase the number of fruits per tree. However, since the pruning of Anjou generally increases the percentage of blossoms setting fruit more than enough to compensate for the reduction in number of flower buds incident to pruning, many growers

BN-29832

Figure 8.—Bartlett trees after pruning: *A*, 5 years old; *B*, mature.

rely on rather heavy pruning. Although satisfactory in some seasons, such heavy pruning stimulates the rate of fruit growth so much that with a moderate crop the final fruit is often larger than desired. Furthermore, with repeated heavy pruning, the yield per tree in some years may be considerably less than that of trees with annual light pruning.

Experimental evidence indicates that over a period of years annual light pruning will produce as great a total yield and with vigorous trees a slightly greater yield than annual heavy pruning. The advantages of the lighter pruning include less cork spot where cork is a problem, more desirable fruit size, and the opportunity for greater yield per tree.

In pruning pear trees, particularly Anjou, emphasis should be placed on the removal of limbs with spurs over 4 to 5 years old. To renew these limbs, an excess of new water sprouts should be left each year. These should be thinned out when they are 2 years old, leaving those that have or, if still needed, those that will set fruit spurs in the coming years. The remainder are removed. These renewal shoots should be left until they have produced one or two crops and then replaced with new or younger fruiting shoots. By a rotation system of this type old spurs are not permitted to develop. Where this system has been rigidly followed, the cost of pruning is not excessive and fruit set and yield have been very satisfactory.

POLLINATION

Numerous pollination experiments show that Bartlett and Anjou are virtually self-sterile. They also show that these varieties may be highly self-fruitful in the West because of the production of parthenocarpic fruits (without seed). However, cross-pollination generally aids in the setting of fruit by all important pear varieties under some, if not all, conditions.

In the Western States good crops of Bartlett and Anjou are harvested where no provision is made for cross-pollination. The degree of self-fruitfulness of these varieties depends on the season and growth status of the tree. If temperatures are relatively cool during the bloom period and immediately following, fruit set in solid blocks of these varieties will be much lower relatively than where cross-pollination is provided. Likewise, the lower the vigor the more likely fruit set will be adversely affected where there is no provision for cross-pollination.

Even where vigor and weather conditions are optimum, cross-pollination generally results in a greater fruit set. This may not be an advantage if the increased set is not needed for an adequate crop, because such a situation would necessitate the removal of surplus fruit in order to obtain adequate size. However, in many fruit areas, particularly in the Northwest, cross-pollination will pay large dividends by increasing yields in more years than not. Also, there are areas in California where Bartlett will benefit in most years with cross-pollination, even though there are many successful orchards of this variety grown in solid blocks.

Most of the fruit in these orchards is seedless and generally has the desirable feature of being longer in proportion to its diameter. The overall size of seedless pears may not be so great as seeded fruit (cross-pollinated), though the experimental information on this point is inconclusive. Seedless pears are more prone to harvest drop than those with seed.

A comprehensive study determined if a seedless Bartlett was the result of stimulative parthenocarpy, caused by the stimulus of self-pollination, or if fruit set was due to vegetative parthenocarpy, which occurs without any pollination. During four seasons of experiments, stimulative parthenocarpy failed to result in a significantly higher set than when pollen was not involved (vegetative parthenocarpy).

Additional evidence was obtained by caging trees with tight mosquito netting, either with or without a colony of bees enclosed. These tests showed that bees working the blossoms failed to increase the self-fruitfulness of the Bartlett pear. It may be concluded, therefore, that bees are of doubtful value in Bartlett orchards unless other varieties are interplanted or are within bee-flight range so that cross-pollination is possible. In the East, Bartlett and most other varieties cannot be depended on to set fruit without cross-pollination.

In providing for cross-pollination, one should consider the commercial value of the pollinizer and when it blooms in relation to the variety to be pollinated. All important pear varieties producing viable pollen are compatible. Bartlett (fig. 9A), like most varieties, produces large blossoms with abundant pollen. The varieties Waite and Magness (fig. 9B) are completely male sterile and obviously will not function as pollinizers. The pollinizer and the main variety must bloom concurrently or their blossoming period must overlap. If sufficient chilling to break the rest period occurs during the dormant season, most pear varieties overlap reasonably well.

Bartlett has a relatively long chilling requirement, whereas Winter Nelis requires much less chilling to break dormancy. Thus, when mild winters occur in the Sacramento Valley, Winter Nelis bloom may be too early to adequately pollinate the later opening Bartlett blossoms. In such instances, Hardy is a preferred pollinizer, since this variety has a chilling requirement similar to that of Bartlett and is likely to bloom at about the same time whether the winter is mild or cold.

Varieties grown in southern regions may vary considerably in time of bloom. For example, Baldwin and Orient, because of their short chilling requirements, may bloom too early to pollinate Maxine or Waite.

In colder areas, the chilling requirement of a variety is of no consequence, because the winters are always cold enough to adequately satisfy all varieties. In the Western States, both Bartlett and Anjou are important varieties and are considered good pollinizers for each other. In Michigan and New York, Bosc is frequently used as a pollinizer for Bartlett.

Often a grower is interested in planting only one variety and would like to have as few pollinizers as possible. In most areas, every fourth tree in every fourth row is adequate. With this pattern, only 6 percent of the trees are pollinizers, and two diagonal spaces represent the maximum distances from the main variety to a pollinizer. However, when practical, closer proximity of pollinizers in Anjou blocks will increase yield (fig. 10). When pollinizers are provided, it is necessary to have an adequate supply of bees to transfer pollen from one variety to another. One strong colony for every 2 acres is generally adequate.

The best time to place bees in the orchard is when the first blossoms open. Pear blossoms are not par-

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Figure 9.—Portion of pear tree in full bloom and individual flower (insert) of: *A*, Bartlett, showing numerous clusters of wide open blossoms with fully developed anthers and abundant pollen; and *B*, Magness, showing sparse individual clusters of smaller, cup-shaped flowers with aborted anthers and no pollen.

ticularly attractive to bees, and placing them in the orchard before blossoming encourages the bees to go elsewhere. Hives do not have to be distributed singly throughout the orchard. Placing them in groups of 5 to 10 in a warm, protected place not only promotes optimum activity but also facilitates handling.

FRUIT SET

Even under optimum conditions of pruning, cross-pollination, and general culture, Anjou pears with heavy bloom in the Pacific Coast States frequently fail to set a capacity crop of fruit. Various types of chemical sprays have been tested to increase fruit set on this variety. In central Washington, boron sprays (50 to 100 p/m) applied during the bloom period appreciably increased the set of Anjou. A probable explanation of the mechanism involved is the correction of an incipient or temporary deficiency of boron.

Fruit set of pears can be increased by cultural management such as pruning, fertilization, and limb positioning. The most effective practice is spreading limbs to the 45° position with the trunk. Limb girdling 2 to 3 weeks after bloom also increases set but may cause girdled area to be more susceptible to winter injury. If used, girdling or scoring should be

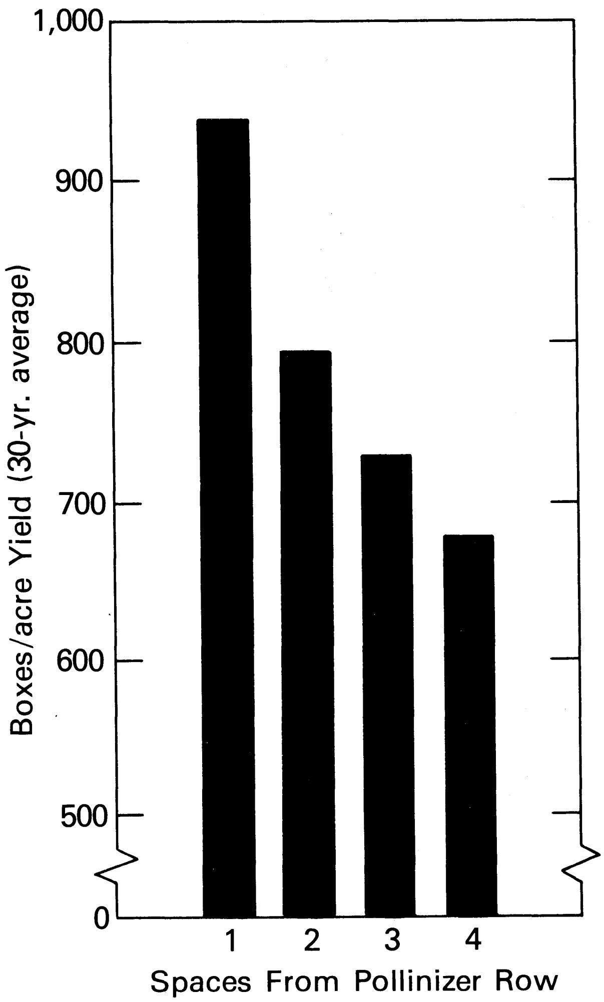

Figure 10.—Anjou pear yield (and average annual yield for 30 years) as related to distance from Bartlett pollinizers (from Westwood and Grim, *1972*).

done on limbs and not on main trunks or scaffolds to avoid danger of winter injury.

Fruit set can also be influenced by applying growth regulators. This work is still in the experimental stages, but holds considerable promise for the future, especially on Anjou.

FRUIT THINNING

Many varieties of pears set heavy crops that do not develop to good marketable size, particularly Winter Nelis, Bosc, and Bartlett. If medium to large fruit is desired, part of the crop from such trees should be thinned in order to have a larger leaf area per fruit. In California, thinning of Bartlett is seldom necessary.

Many pear varieties, such as Bartlett, Hardy, and Bosc, tend to set the fruit in clusters, often three to five fruits on a single spur. If the set of fruit on the tree as a whole is excessive, these clusters should be reduced to one or two fruits each by removing the smaller ones. On the other hand, if the set of fruit on the tree as a whole is not excessive, fruit in these clusters will reach satisfactory size and quality without thinning.

It is impossible to lay down hard-and-fast rules for the thinning of pears. The number of fruits a tree will develop to good marketable size will vary with its vigor and growing conditions. Experiments indicate that with nearly all varieties from 30 to 40 good leaves per fruit are essential for the manufacture of materials that produce fruit. However, these leaves need not be directly adjacent to the fruit. With extremely heavy sets of fruit, thinning to reduce the amount of fruit in proportion to the leaf system is essential if fruit of best size and quality is to be obtained. Since fruit that is small at thinning time tends to remain so, it should be removed at that time.

As the natural drop is usually over about 6 weeks after bloom, the earlier the thinning is done after this the greater is the effect on improving the size of the remaining fruit.

In some areas, particularly California, growers rely solely on selective picking to supply the necessary thinning. When pears of 2-3/8 inches in diameter and larger are removed in the first picking, the fruit remaining on the tree will likely increase in volume at a daily rate of about 2 percent. Thus, about 1 week is required to obtain an increase of 1/8-inch diameter for the remaining fruit. Bartlett pears, however, should not be permitted to remain too long on the trees for size increase, since both shipping and canning quality may be seriously impaired. This practice is seldom used in Oregon or Washington.

Chemical Fruit Thinning

High labor costs have encouraged the use of chemicals for thinning Bartlett pears. The ideal practice is to remove most of the excess fruit with chemical sprays and use supplemental hand thinning to adjust the fruit load. Quality of remaining fruit is improved by hand removal of the small, marked, and misshapen fruit.

Fruit set and size of Bartlett pears have been determined after spraying with different rates of naphthaleneacetic acid (NAA) and naphthaleneacetamide (NAAm). Both NAA and NAAm reduce fruit set (table 8). NAAm is used at a rate of 10 to 15 p/m. NAA is used at a rate of 15 to 20 p/m. The most effective time of application is at 15 to 20 days after full bloom. NAAm sometimes causes overthinning. NAA usually will not cause overthinning. Chemical thinning can increase size of remaining fruit by up to 18 percent. However, the increase in size of the fruit is generally small considering the earliness of thinning and the amount of thinning obtained (table 8).

The grower should know at hand-thinning time which fruit will be large enough at harvest to satisfy the market requirements. After chemical thinning

Table 8.—Fruit set and increase in size of remaining fruit after chemical thinning of Bartlett pear orchards in 3 different years[1]

Year, chemical, and concentration (parts per million)	Orchard 1		Orchard 2		Orchard 3		Orchard 4	
	Fruit set[2]	Size increment[3]	Fruit set	Size Increment	Fruit set	Size Increment	Fruit set	Size Increment
	Number	*Percent*	*Number*	*Percent*	*Number*	*Percent*	*Number*	*Percent*
First year:								
Check	60	0	55	0	42	0	-	-
NAA 5 ..	53	8	43	6	43	0	-	-
10 ..	44	6	39	11	44	6	-	-
NAAm 10 ..	55	6	34	9	40	4	-	-
20 ..	39	9	33	6	38	4	-	-
Second year:								
Check	45	0	51	0	60	0	60	0
NAA 10 ..	35	5	35	7	40	11	40	4
NAAm 15 ..	25	12	25	15	22	11	25	15
Third year:								
Check	62							
NAA 15 ..	32	18						
NAAm 10 ..	34	9						

[1] Sprayed 14 days after bloom with NAA, naphthaleneacetic acid, or NAAm, naphthaleneacetamide as indicated.

[2] Number of fruit per 100 blossoming clusters.

[3] Based on 100 fruit measured at random from each of 5 trees per treatment.

and in light crop years, the tendency is to overthin the remaining fruit and seriously reduce profits. Many growers space-thin pears, using the same spacing of 8 to 10 inches as used for apples, with the assumption that a similar increase in size of remaining fruit is obtained with pears as with apples. Research on fruit growth after chemical and hand thinning indicates that pears do not benefit from thinning to the same extent as apples. Therefore, the practice of heavy thinning by spacing of fruit to increase fruit size should be avoided, especially on young, healthy trees.

Size Thinning of Fruit and Harvest Size Prediction

A method of predicting harvest size at thinning time has been developed and is presented as a guide for size thinning Bartlett pears. Table 9 is used for predicting the final size of fruit at harvesttime. The data are from 10 years of actual fruit measurements at Wenatchee, Wash., and are useful in determining which fruits will be too small to meet grade standards at harvest. If a 2-1/4-inch-diameter pear is desired at a harvesttime of 125 days from bloom, the fruit should be a minimum of 1.06 inches in diameter at 60 days from bloom (table 9). If harvest date is advanced to 110 days from bloom, the fruit should be 1.26 inches in diameter at 60 days from bloom to meet the desired harvest size of 2-1/4 inches. All fruits smaller than these measurements should be removed at thinning time. A small pear grows at about the same rate as a large one, but because it is small to begin with it will be smaller at harvesttime regardless of the amount of thinning done.

The correlation between early fruit size and final harvest size is very high. At 60 days after bloom, the final size can be predicted to within one-eighth inch in diameter 90 percent of the time. This close correlation is undoubtedly due to the uniform growth rate of pears. Because of this close correlation, the data in table 9 can be used as an excellent guide for size thinning Bartlett pears. Some variation in results will occur in different pear districts because of climatic differences and specific cultural practices such as frequency of irrigation and fertilization. However, adjustments can be made by the individual grower at thinning time to allow for the effect of climate, high or low tree vigor, and cultural practices on fruit growth. For example, it may be necessary to leave only the fruit which is large enough at 60 days from bloom to obtain 2-1/2-inch pears at harvest, rather than smaller ones predicted to be 2-1/4 inches in diameter. This would allow a margin of safety for adverse growing conditions.

Hand thinning of Bartlett pears after 70 days from bloom does not result in an appreciable increase in size of the remaining fruit. Most of the benefit from thinning at that time is in removal of cull fruit and, in some cases, larger sound fruit to prevent limb breakage. Contrary to popular belief, Bartlett pears on healthy trees can be left in clusters of two or three and still attain desirable quality and harvest size, provided the tree is healthy and the limb will support the fruit load. This can be done because improved spray practices control insect pests, and the increase in fruit size obtained from space thinning or thinning to one fruit per spur is small.

Many growers are using size thinning to improve quality and yield of pear fruit. On a given day, a thinning crew can be given a sample fruit and instructed to remove all fruit smaller than the sample fruit and if necessary do some space thinning to reduce limb breakage. This system prevents overthinning of trees capable of carrying and sizing heavy crop loads.

Table 9.—Harvest size predictions for Bartlett pears

Fruit size at designated days from full bloom							
Size prediction period				Harvest period			
60	65	70	75	100	110	120	125
Inches in diameter							
1.06	1.17	1.28	1.37	1.87	2.04	2.19	2.25
1.17	1.28	1.39	1.49	1.98	2.15	2.30	2.36
1.26	1.37	1.48	1.58	2.10	2.27	2.43	2.49
1.34	1.46	1.57	1.68	2.22	2.40	2.55	2.62
1.43	1.55	1.66	1.78	2.33	2.52	2.68	2.74
1.51	1.63	1.75	1.87	2.44	2.63	2.80	2.87
1.63	1.75	1.87	1.99	2.56	2.76	2.93	3.00
1.75	1.87	1.99	2.11	2.68	2.88	3.04	3.12

HORMONE SPRAYS TO PREVENT FRUIT DROP

Dropping of fruit before or during harvest causes considerable loss in some years. This is especially true in solid blocks of Bartlett rendered seedless for lack of cross-pollination. This loss can be greatly reduced by the use of hormone sprays on most varieties where drop is a serious problem.

Such sprays are now used generally by commercial pears growers. NAA has been effective for this purpose when used at a strength of 5 to 10 p/m. In most sections of California, NAA is usually incorporated in a mite spray, which is applied 2 to 7 days before harvest. The spray becomes effective within 2 or 3 days and generally controls drop for 3 to 5 weeks.

When hormone sprays are used to prevent the natural drop of fruit, it is important that the fruit be harvested at the proper stage of maturity; it should not be allowed to remain on the tree too long. Overripe pears, particularly Bartlett, break down soon after harvest.

PRINCIPAL PEAR VARIETIES

Pear varieties may be classified into two broad groups—the French types, or those of European origin (*Pyrus communis* L.), and the hybrid types, which originated as crosses between European varieties and oriental species. In general, the European varieties are much higher in quality but more susceptible to fire blight. Because of this, the hybrid types are better adapted to southern conditions.

French Types— *Pyrus communis* Origin

Anjou

Anjou (fig. 11), a large green pear of French origin, has been grown in the Pacific Coast States over a long period, but most plantings have been made since 1920. It is the most important winter pear and second only to Bartlett in total production. Anjou is grown mainly in Washington and Oregon, with limited plantings in California.

The fruit is attractive and high in dessert quality. It keeps well in storage until March or April or slightly longer in sealed polyethylene liners, and may be marketed over a long period. The entire commercial crop is marketed as fresh fruit. The tree is vigorous and grows large. This variety is more resistant to fire blight than other large high-quality varieties. It is a consistent bearer but a slow producer. Rather heavy and detailed pruning improves fruit set on older trees.

Bartlett

Bartlett (fig. 11) is grown on almost three-fourths of the pear acreage of the Western States. It is also an important commercial variety in Michigan and New York. Nearly two-thirds of the crop is canned. About one-third is sold as fresh fruit and is shipped to all parts of the United States. Small quantities are dried.

The trees are adapted to a wide geographical range and to a great diversity of soil and climatic conditions. They are prolific, bear regularly, and endure neglect, abuse, and uncongenial surroundings surprisingly well. These characteristics, combined with the quality and uses of the fruit, make Bartlett a remarkable variety.

When well grown, Bartlett is generally considered the standard of excellence by which other pears for fresh-fruit shipment are measured. It is the only variety in the West to be used for all purposes. In flavor and texture it is unsurpassed among the major commercial varieties. It is the first of these varieties to ripen. The picking season ranges from early July in the valleys of central California to late August or early September in other areas where this variety is grown.

The fruit may be held successfully up to 2-1/2 months in conventional cold storage. It is normally off the fresh-fruit markets by the middle of October. Bartlett is best both in dessert and in storage and handling qualities when grown under fairly hot summer conditions. In the coastal sections of all the Pacific Coast States where summers are very cool, the fruit does not keep so well after harvest as in the hotter interior sections and usually is less rich in flavor. Fruit from these coastal sections is generally canned or used locally, as the carrying quality is not sufficiently good to allow shipment to distant markets.

Bosc

Bosc (fig. 11) is grown on about 2,000 acres, mainly in the Rogue River Valley of Oregon where

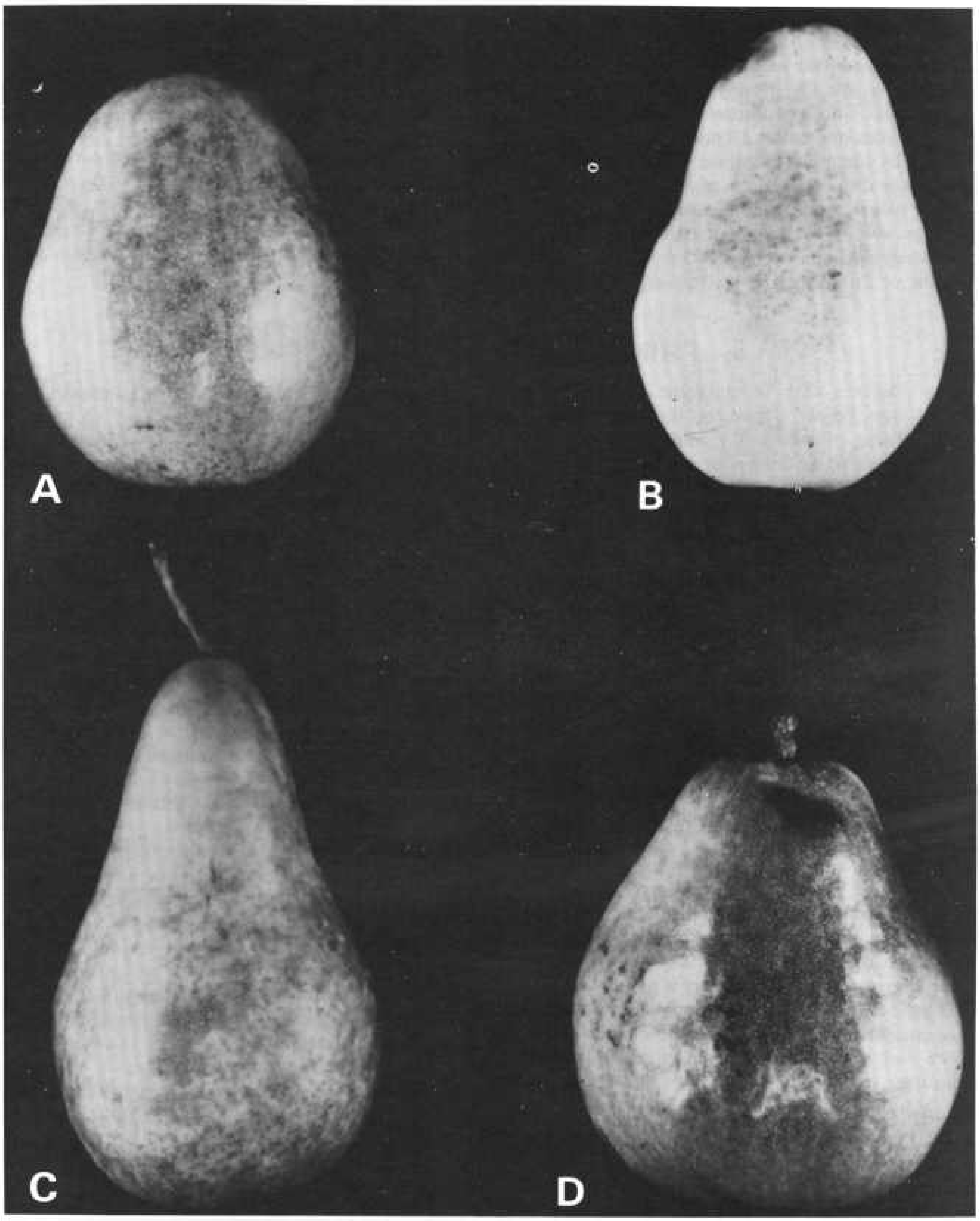

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Figure 11.—Important pear varieties of European origin: *A*, Anjou; *B*, Bartlett, *C*, Bosc; *D*, Comice.

the fruit is excellent. It is also an important variety in New York and Michigan.

The fruit grows to good size. The yellow skin, which is almost covered with a brown russet, is particularly attractive. It is a fall and early winter fruit, reaching prime market condition in October and November. The tree bears rather early and produces heavy crops.

The tree, particularly while young, is difficult to shape by pruning. The branches produce vigorous new shoots from their terminals. These remain rather slender for a considerable time and branch but little, so that the tree remains open and often becomes ungainly and willowy by the spreading of the slender branches. Special attention is required to maintain a tree of desirable shape.

Trees of this variety are attacked by fire blight about as seriously as those of any other commercial variety. The fruit may be seriously affected by stony pit virus. The tree is less tolerant of poor soil drainage than many other varieties.

Comice

In the Santa Clara Valley of California and the Rogue River Valley of southern Oregon, Comice (fig. 11) is grown on nearly 2,000 acres. This tree is open and rather easily managed by pruning, but it is not so consistent in bearing habits as many other varieties, often setting very light crops.

The fruit is large, light greenish yellow, and of excellent dessert quality. In flavor it is among the very best of the pears. It keeps well if handled carefully and can be held in cold storage into January. However, it is one of the most easily bruised of the commercial varieties. The skin is tender and easily punctured, and even light bruises at picking time will result in darkened areas on the fruit. It is also readily injured by the rubbing of the leaves and branches. In recent years much of the crop has been marketed for gift packages and other channels where special handling can be given.

Hardy

Hardy is grown on about 1,500 acres, mainly near San Francisco Bay and in the Santa Clara and San Juan Valleys of California. The tree grows well, is a heavy bearer, and appears to be more resistant to fire blight than Bartlett.

It is rather easily handled by pruning, because it is not inclined to branch freely and remains open. Much of the new growth takes place at the terminals of fruiting branches or where branches are headed back or removed. Numerous large fruiting spurs instead of shoots develop along the fruiting branches and remain vigorous and productive for many years. The wood unites well with quince and is frequently budded on quince roots and then topworked to other varieties.

The fruit is of good size and shape, keeps and handles fairly well in storage, and attains an attractive flavor. It ripens soon after Bartlett and before Bosc and Anjou. It was a favorite for export prior to World War II, but now it is largely used in canned fruit mixes and baby foods.

Maxine

Maxine is well adapted to most areas of the South. It ripens in mid-September between Orient and Kieffer. The fruit is large, attractive in shape, and yellow when ripe. The flesh is average in firmness and moderately gritty, with flavor and quality above the average of hybrid pears. It is suitable for eating fresh and rated high as a canned product. The tree is vigorous, productive, and generally rather tolerant to fire blight.

Seckel

Seckel is more tolerant to fire blight than any of the principal varieties of the French type. Because of this characteristic it can be grown successfully under a wide variety of climatic conditions, including areas throughout the South. The fruit is small but of excellent flavor and quality. The tree comes into bearing late, but is usually very productive as a mature tree. This variety is of limited commerical value because of its small fruit, but it is highly prized for home use and local markets.

Hybrid Types— *Pyrus communis* Crossed With Oriental Species

Baldwin

Baldwin, because of its low cold requirement to break dormancy, is an excellent variety for the lower South. If planted in the middle and upper South, however, it may bloom too early, and consequently spring frosts are likely to cause loss of crop. The fruit is almost round and golden yellow when ripe. Its fresh and processed qualities are considered good for a hybrid variety.

Kieffer

Kieffer is perhaps the most widely planted pear in the Southern and lower Midwestern States. It is grown chiefly for home consumption.

The trees are vigorous and well adapted to a wide geographical range and to a great diversity of soil and climatic conditions. Its moderate fire blight resistance makes it possible to grow this variety in areas where many European varieties succumb to this disease. Kieffer blossoms relatively early and is unfruitful with its own pollen. It, therefore, requires the presence of another variety blossoming at about the same time to set heavy crops of fruit.

Kieffer matures in late September or October, depending on the area. The fruit is medium to large, developing an attractive color when ripened properly. Its flesh is firm, moderately juicy, and gritty. Although the dessert quality is low, the canned product is usually good.

Orient

Orient ripens in late August or early September. It blooms several days earlier than Kieffer and has outstanding resistance to fire blight.

The fruit is large, nearly round, and greenish, with juicy flesh that is firm and only moderately gritty. It is only fair as a fresh fruit, but the canned product is attractive in appearance and of good quality. The tree is vigorous and productive, with a willowy type of growth becoming almost weeping under a full crop of fruit. Orient is recommended for planting throughout the Southern States.

Waite

This variety possesses a high degree of fire blight resistance and is well adapted to the middle and upper South. Waite was introduced by USDA in 1938. Its fruit resembles that of Moonglow but is smaller in size. The quality is fair to good. The seasons of Waite and Kieffer are the same. Waite flowers are male sterile.

NEW VARIETIES

El Dorado

El Dorado orginated about 1925 as a chance seedling near Placerville, Calif. During the past few years, considerable interest has developed in this variety, and several hundred acres have been planted in Oregon and Washington.

El Dorado is a winter-type pear of European origin, which fits well into the late marketing season. It is harvested just after Anjou and usually with Comice. The fruit is distinctly pyriform in shape, often resembling the Bartlett variety, clear skinned, and with a moderately long, flexible stem. The fruit is as large as Bartlett, and the flesh is essentially free of stone cells. The skin becomes an attractive pale yellow when the fruit is ripened.

In limited storage tests, El Dorado has not developed scald or core breakdown. The fruit will store well at 30° F (-1.1° C) until April and May. Taste tests indicate it has excellent quality.

The fruit is moderately free of blemishes and russeting and resists mechanical injury as well as Bartlett and Anjou. Shelf life for Eldorado is as long as Anjou and longer than Comice or Packham's Triumph. The fruit also resists pressure and friction bruising.

This variety has not been widely tested and should be planted only on a trial basis until more is known of its performance.

Packham's Triumph

Packham's Triumph originated in New South Wales, Australia, and was introduced there commercially about 1900. It is a European-type pear. It was introduced into the United States about 1945. Several commercial plantings have been made in Oregon and Washington.

The fruit is large and similar to Bartlett in shape, except that the surface is likely to be rough and irregular, particularly on the larger fruit. The skin is lemon yellow when ripe. The flesh is fine textured and juicy, with a particularly rich and pleasing flavor. Packham's Triumph matures about 30 days after Bartlett and keeps well in cold storage for 4 to 5 months. The tree is upright, vigorous, and a good producer, but highly susceptible to fire blight.

Varieties Recently Introduced

ARS introduced Magness, Moonglow, and Dawn (fig. 12), which were developed at Beltsville, Md., from 8,000 seedlings of the pear-breeding program. They were all derived from European varieties. All three are moderately to highly fire blight resistant, and the fruit are considered good to excellent in quality. These varieties have not been widely tested and should, therefore, be planted on a trial basis until more is known of their performance.

The picking maturity of Magness is 10 to 14 days later than that of Bartlett. The fruit is lightly covered with russet, medium size, and generally oval. The flesh is soft, very juicy, and almost free of grit cells. The mature fruit has a sweet flavor and is highly aromatic. When in prime condition, it rates with the highest quality pears. It can be held in storage up to 3 months and ripens with good quality. The tree is very vigorous and spreading and highly fire blight resistant; however, in Maryland trees have died from trunk blight (fig. 23 *C*). Magness is male sterile.

Moonglow is mature for picking about 7 days before Bartlett. The fruit is attractive, has rather soft flesh, is moderately juicy, and is nearly free of grit cells. The flavor is mild and subacid. The fruit is considered good for processing as well as fresh consumption. The tree is vigorous, upright in habit, and resistant to fire blight. Moonglow is recommended for trial, especially in areas where fire blight is a major problem.

Dawn matures about 10 days earlier than Bartlett. The fruit is pyriform, generally resembling Bartlett in shape. It will average slightly smaller than Bartlett. The fruit is very good in quality and is aromatic, sweet, and very juicy. It is almost entirely free of grit cells. The tree is only moderately vigorous and perhaps is no more resistant to fire blight than Bartlett. It is recommended for trial as a relatively early variety in areas where Bartlett can be grown satisfactorily.

Some more recent selections are red-fruited mutants of the green or yellow pear varieties, and other selections are from breeding programs of individuals and institutions. The following are the best introductions and a description of them by storage season:

Very Early Storage Season (Less Than 1 Month)

Starkcrimson is a red sport of Clapp's Favorite with equivalent shape, quality, and handling as Clapp's. It has an attractive red fruit with good eating quality of melting texture and sweet juicy flavor. It blooms with Bartlett, but should be harvested 1 week before Bartlett harvest.

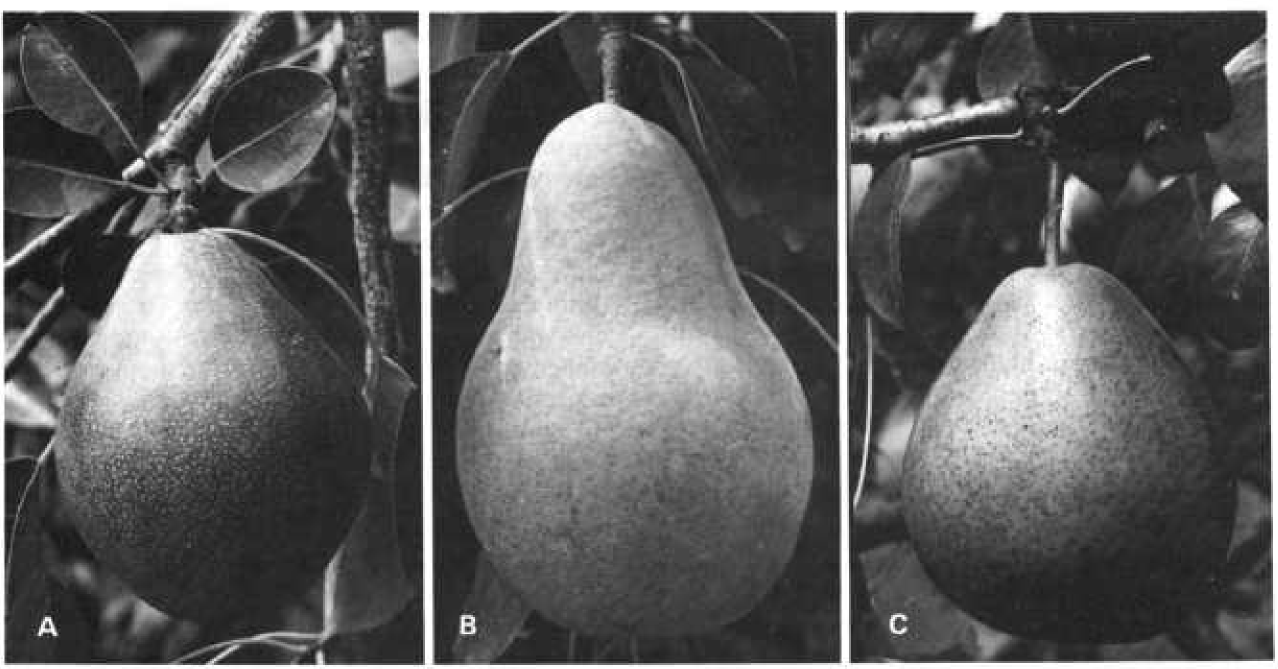

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Figure 12.—Pear varieties released bv U.S. Department of Agriculture: *A,* Magness; *B,* Dawn; and *C,* Moonglow.

Early Storage Season (2-1/2 to 4 Months)

Butirra Precoce Morettini is an Italian variety of excellent quality, precedes Bartlett harvest by a week, but stores as long as Bartlett (2-1/2 months). The fruit is about 2-3/4 inches in diameter and pyriform in shape with a bright, blushed, yellow skin. The fruit should be picked at 15 to 17 pounds pressure. When ripened, it has a melting texture and tart flavor (soluble solids 14 percent). The tree crops well and regularly with cross pollination.

Butirra Rosata Morettini is an Italian variety with slightly less quality than Precoce Morettini, but is harvested during Bartlett season at 15 to 17 pounds and stored 2-1/2 months. It is larger (3 inches in diameter) and coarser in texture but handles better than Bartlett or Precoce.

Sensation Red Bartlett or Mock's William is a red-fruited sport of Bartlett with similar characteristics to the Max's Red Bartlett except that fruit quality, skin color, and handling are superior. Reversion to green Bartlett has not been as likely as with Max's Red.

Rosired Bartlett is another red sport of Bartlett with similar characteristics except with a solid maroon skin. Harvesting should be made about 1 week after Bartlett.

Reimer Red is a Comice x Max Red Bartlett hybrid developed by Reimer in the Rogue River Valley. To keep well in storage through December, the red blush fruit should be harvested at time of late Anjou or early Comice harvest. The fruit is pyriform in shape, 2-1/2 inches in diameter, and juicy and sweet (soluble solids 15 percent). The tree crops moderately and regularly.

California (Max Red Bartlett x Comice hybrid) came from the University of California at Davis breeding program. To keep well in storage through December, the fruit should be harvested at 15 to 18 pounds pressure at time of Bartlett harvest. Fruit diameter is 3 inches, and fruit shape is variable, oval, obtuse, and pyriform. The fruit skin has a green ground color at harvest, which becomes yellow with red blush whenripe. The texture, juiciness, and soluble solids (15 percent) are similar to Comice. Bloom occurs slightly earlier than Bartlett.

Midstorage Season (5 Months)

Butirra di Roma is an Italian variety of excellent quality with a blushed yellow skin. The fruit is about 2-3/4 inches in diameter with a pyriform shape if picked at time of Bartlett harvest at 16 to 18 pounds pressure. The fruit is moderately resistant to abrasive marks, making handling comparable to Bosc. The fruit is melting with some grittiness, juicy, and sweet (soluble solids 14 percent).

Red Comice is a red fruit mutant of Comice. It has the same characteristics as Comice except with slightly longer fruit with red stripes. Red Comice has been compatibly grafted on quince rootstock.

Late Storage Season (8 months)

Red Anjou is the red sport mutation of Anjou with the same fruit characteristics except with a solid red skin. The fruit is small (2-1/4 inch diameter) if picked during Anjou harvest for late storage, but Red Anjou can be picked 2 weeks later for better size at the expense of a shorter storage. Red Anjou trees have lacked vigor like some of the other red varieties.

Rogue Red (Comice x Seckel x Farmingdale hybrid) was developed by the Southern Oregon Experiment Station. Rogue Red fruit is as sweet as (soluble solids 17 percent), but drier and grittier than Comice and can be kept in storage as late as Anjou. The red blush fruit varies in shape and is large (3 inches in diameter). Rogue Red can be picked during Comice and Bosc harvest at 13 to 15 pounds pressure. Harvests of Rogue Red are generally improved with cross pollination. Rogue Red is compatible on quince. Bloom occurs at some time between that of Anjou and Bartlett, or later.

Asian Pears

Asian pear varieties from China and Japan are *P. serotina* and *P. ussuriensis* or their hybrids. Several have been tested and grown throughout a number of U.S. regions. These pears are called "apple-pears" in the U.S. markets because the fruit is aromatic, crisp, juicy, and sweet, and the subacid flavor is unlike "European" pears. The trees of these "Oriental" varieties are quite resistant to fire blight and bacterial canker, but the Japanese varieties are more attractive to pear psylla than are the Chinese varieties.

The major variety grown in Yakima and in the Sacramento Valley is Nijisseiki (Twentieth Century), which is harvested in early September and can be stored at temperatures above 32° F (O° C) for several months. The fruit is round and has pale, yellow, waxy skin. A few promising varieties, which could replace Nijisseiki, have been tested and grown in Japan and the west coast of the United States. Two varieties are Shinseiki (New Century), which is smaller fruited and matures 10 days earlier, and

Chojuro, which has the same shape, size, and harvest date as Nijisseiki but with russetted skin.

Of the Chinese varieties tested in California and Oregon, Tsu Li and Ya Li show the most promise. Tsu Li has a large (3 inches in diameter), blocky, pyriform, light-green fruit with russetted lenticels. It matures in early October and can be stored for 5 months in above-freezing temperatures. Ya Li is similar but smoother and more pyriform. Trees of both varieties have been vigorous and productive.

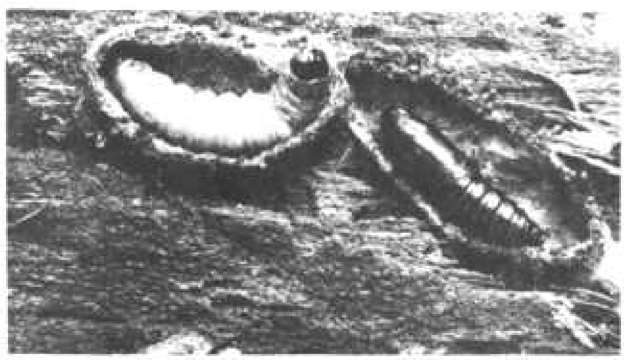
PEAR INSECTS

Pears cannot be grown profitably on a commercial basis without adequate control of insect and mite pests. Before satisfactory control measures can be applied, the pest species must be identified. Because control programs may change rapidly and should be adapted to conditions present in your growing area, information on specific control programs, trapping, and other pertinent information should be obtained from a licensed pest control consultant, county agricultural agent, or personnel of the State agricultural experiment station or the USDA.

Codling Moth

One of the most serious insect pests of pears is the codling moth (*Laspeyresia pomonella* (L.)), which must be controlled with a regular, annual spray program, carefully timed and thoroughly applied. The insect is injurious only in the larval, or worm, stage. Young larvae burrow into the fruit, either through the stem or calyx ends or in the side, usually at points where two fruits touch or where a leaf touches a fruit. After feeding beneath the skin for a few days, the larvae go to the center of the fruit, where they feed on the seeds and core. When full grown, they tunnel to the surface and leave the fruit. Their presence is often evident from the brown frass that plugs the holes. Wormy fruit is of no value.

Codling moths winter as mature larvae in cocoons under the loose bark of trees (fig. 13), in cracks, crevices, or bark wounds, and in litter on the ground. In the spring the larvae pupate, and in a short time the adult moths (fig. 14) begin to appear, usually soon after the trees have bloomed. They continue to emerge for some weeks, the period extending through part of May and June. Moths are inconspicuous and are most active at twilight. Eggs are laid on fruit and leaves on evenings when the temperature is above 60° F (15.6° C). They hatch in 6 to 14 days, depending on the temperature, and the larvae feed in the fruit for 3 weeks or longer. In Northern pear-growing areas, there may be only one generation and a partial second, but in some areas with longer growing seasons, as on the Pacific coast, there may be as many as three generations.



PN-5767

Figure 13.—Codling moth larva and pupa in cocoons.

BN-29813

Figure 14.—Codling moth adult.

Oriental Fruit Moth

The oriental fruit moth (*Grapholitha molesta* (Busck)) occurs in most of the pear-growing districts of the United States. It attacks pear as well as other deciduous fruits. The pinkish-white worms burrow into the fruit in much the same way as those of the codling moth, and they cannot be readily differentiated. These pests hibernate in cocoons as full-grown worms, and there are several generations in a season. Ordinarily, if the codling moth is controlled on pears, the oriental fruit moth will not cause much damage. Sex pheromone baited traps are also available for the oriental fruit moth. These traps can be useful in a manner similar to that for the codling moth.

Leafrollers

Several species of leafroller moths attack pear fruit in various areas of the United States. In recent years, infestations of the fruittree leafroller (*Archips argyrospilus* (Walker)) have become more common in western pear orchards. Fruittree leafrollers overwinter as egg masses on the twigs and limbs. The eggs hatch in early spring and the young larvae feed on leaves, tying them together or folding over an edge of a single leaf and tying it down with silk. The larva lives within the tunnel thus created. The adults emerge in late spring or early summer depending upon geographic location and lay eggs which will give rise to the second generation. Damage caused by the feeding of the larvae on the fruit consists of deep, irregular holes with rough scar tissue. Young fruits, which are fed upon, may remain small and become misshapen.

The redbanded leafroller (*Argyrotaenia velutinana* (Walker)) is primarily a pest of apple in the Eastern United States but will also attack pear. Redbanded leafrollers overwinter as pupae within a folded leaf in the ground cover. Adults emerge in mid- to late spring, and the eggs are laid in masses on the trunk and scaffold branches shortly after emergence. The larvae feed on both leaves and fruit. Damage caused to the fruit is similar to that caused by the fruittree leafroller. Two full generations are produced in New York.

Treatments applied for control of codling moth usually will also control leafrollers. Where standard control programs are modified, a treatment at petal fall may have to be applied for control of these pests. Sex pheromone baited traps are available for some of these leafrollers, and when properly used they can furnish information on presence of a given species, occurrence and timing of flights, relative abundance, and effectiveness of control programs.

Pear Psylla

The pear psylla (*Psylla pyricola* Foerster) is a serious pest of pear, sometimes even more injurious than the codling moth. It has been in the Eastern States for over 100 years and appeared about 1939 in Washington. From there it spread to practically all pear-growing districts on the Pacific coast. Honeydew secreted by these insects runs down over the foliage and fruit, and a sooty fungus grows in it. This causes the skin of the fruit to become blackened and scarred, and the foliage develops brown spots. Heavy infestations may cause partial defoliation of the trees, reducing vitality and preventing the formation of fruit buds. There is strong evidence that the pyslla is associated with the development and spread of pear decline disease.

Pear psylla adults (fig. 15) have somewhat the appearance of miniature cicadas, with transparent wings sloping over the body. They are about one-

BN-29814

Figure 15.—Pear psylla adult.

tenth inch long and dark reddish brown. They can fly suddenly from where they are resting, giving the impression they have jumped. Adults of the overwintering form are larger and darker than those of the summer form. They hibernate in crevices in the bark and on the ground. The adults may become active at any time when the temperature is above 40° F (4.4° C).

The elongated whitish or yellow eggs are deposited in March or sometimes earlier in small crevices about the buds and hatch in 10 to 30 days. After the foliage is out, many eggs are deposited on the leaves. The young nymphs migrate to the axil of the leaves or to the opening leaves themselves to feed. They are yellowish and flattened and soon cover themselves with the honeydew they secrete. After going through four successively larger stages and becoming greenish, they reach the last, or "hard-shell" stage (fig. 16), from which they molt into adults. There may be three to five generations a year, the first one lasting about 45 days and the later ones about 30 days. Adequate control is often difficult to obtain, and any treatment must be carefully timed and thoroughly applied.

Scale Insects

The San Jose scale (*Quadraspidiotus perniciosus* (Comstock)) may cause serious loss of pears if not controlled, for it infests not only the bark and foliage but also the fruit (fig. 17). The scale occurs in most pear-growing areas and has a wide host range, including many ornamental trees and shrubs as well as deciduous fruit trees. Trees may be partially or entirely killed by heavy infestations. Under light infestations, damaged fruit can be culled out.

The scales are about one-twelfth inch in diameter, with yellow bodies protected by circular, grayish, scalelike coverings. Each mature female produces several hundred small, louselike, yellow crawlers, which migrate to new locations. These crawlers may be scattered about by wind, birds, or other means. Feeding is through a sucking beak. There are two or more generations a year.

In the Pacific States, the dormant or delayed dormant sprays are most important in control of San Jose scale. In heavy infestation situations, one or two sprays, in addition to the dormant or delayed dormant stages and directed towards the crawler stages, should be applied when crawlers are active in the summer.

In California, pears may be infested with the Italian pear scale (*Epidiaspis leperii* (Signoret)), which has habits and a superficial appearance similar to the San Jose scale. However, the soft bodies beneath the scales are reddish purple instead of yellow. Two other scale insects, the calico scale (*Lecanium cerasorum* (Cockerell)) and the European fruit lecanium (*L. corni* Bouche), attack pears in California, and the latter may occasionally be found in the Northwest. They are 1/8 to 3/8 inch in diameter. They are convex, brown, and, in the case of the calico scale, have irregular white marks. The adults live only on the twigs or limbs, but the flattened young usually feed on the leaves, where they produce large amounts of honeydew in which a black fungus grows. Control of these scales, if done during the dormant period, is not difficult.

The cottony maple scale (*Pulvinaria innumerabilis* (Rathvon)) sometimes becomes a pest on Winter Nelis and Anjou, but is seldom seen on Bartlett. Cottony maple scale is primarily a pest of maple. This scale is easily recognized by the cottony egg sac produced early in the summer. About 3,000 eggs are laid in this sac, and they hatch during June and July. The young scales settle on the underside of leaves, and the partly grown females later migrate to the twigs, hibernating there and completing their growth in the spring. At this time they are brown, convex, and about one-eighth inch in diameter. After the egg sac is formed and the eggs are laid in it, the female dies. There is only one generation a year. Applications of dormant sprays, as used for the San Jose scale, control this scale very well. Several other species of scale insects occasionally may be found on pears.

The grape mealybug (*Pseudococcus maritimus* (Ehrhorn)) is found throughout the Pacific Coast States and is an important pest of pear in California. These insects overwinter on the scaffold limbs in egg sacs as young crawlers. They migrate early in the spring and start feeding on the tender growth. When full grown, they are about one-fourth inch long, dark purple, and covered with a white powdery wax. Oviposition occurs late in June beneath the bark scales and at the base of new growth. This generation becomes adult by late summer. Injury results from honeydew dripping onto the fruit. Some of the mealybugs may also crawl into the calyx end, where their feeding breaks down the tissues. Control is more difficult than with the other scale insects on pear, but good control can be achieved by properly timed and applied sprays directed towards the crawlers in spring and summer.

Orchard Mites

Orchard mites are important pests of pear, often doing great harm. Included are the European red mite (*Panonychus ulmi* (Koch)), the brown mite (*Bryobia rubrioculus* (Scheuten)) (fig. 18), the two spotted spider mite (*Tetranychus urticae* Koch), the McDaniel spider mite (*T.mcdaniel* McGregor), and the yellow spider mite (*Eotetranychus carpini borealis* (Ewing)). The first two winter in the egg stage on

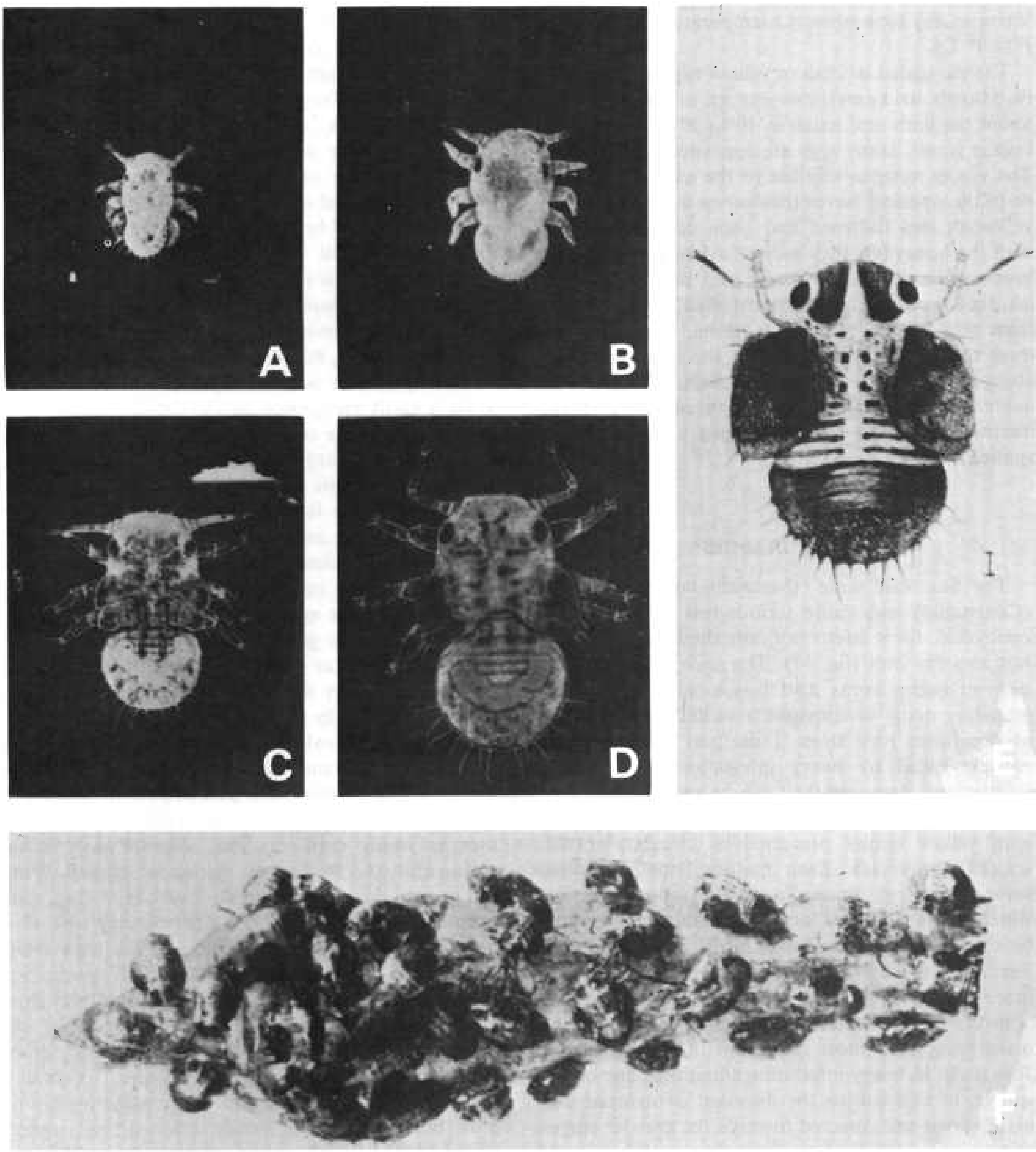


Figure 16.—Pear psylla nymphs: *A*,— *E*, Young stages; *F*, fifth, or "hard shell" stage on pear twig. BN-29822

BN-29821
Figure 17.—Pear infested with San Jose scale.

trees. The red eggs usually hatch before the blossoms open, and the young mites feed on the developing foliage. The European red mite adult is velvety red and very convex. The brown mite is dull red to greenish, flattened, and has longer legs. The brown mite feeds mostly at night, congregating on twigs and branches during the day.

The spider mites winter as bright-yellow or orange adults under bark scales and in debris on the ground, migrating to the buds or new foliage as soon as it develops, feeding first on the leaves nearest the trunk. When feeding, they are yellowish or greenish, often with two dark spots on the back. They spin considerable webbing.

Development of orchard mites is rapid in warm weather. There may be eight or more generations in a season. This makes control difficult and measures must be taken before serious injury occurs. The damage caused by these mites is primarily to the foliage, which becomes bronzed in appearance; defoliation may occur and seriously interfere with the normal development of the fruit.

Two other much smaller mites live on pear—the pearleaf blister mite (*Eriophyes pyri* (Pagenstecher)) (fig. 19) and the pear rust mite (*Epitrimerus pyri* (Nalepa)). Neither can be seen easily without a hand lens. The pearleaf blister mites winter under bud scales, and the young of the new generation form characteristic blisters on the unfolding leaves in which the mites live. Damage usually first appears on the foliage as blisters; feeding on the fruit before and during the blossom period produces depressed, russeted spots. The postharvest and delayed-dormant stages are the best times to apply sprays for control of the pearleaf blister mite. While early postbloom sprays also help to control infestations, sprays applied at this stage may be too late to prevent injury to the fruit and foliage.

The pear rust mite is an important pest of pears in most areas of the West. These mites overwinter behind loose bud scales or in crevices in the bark. They become active in the spring as new plant growth develops and feed on leaf surfaces and on the fruit. Infested foliage bronzes as the mites feed; on fruit, damage takes the form of a smooth russeting of the skin, usually first appearing below the calyx later spreading over the fruit surface. Detection of rust

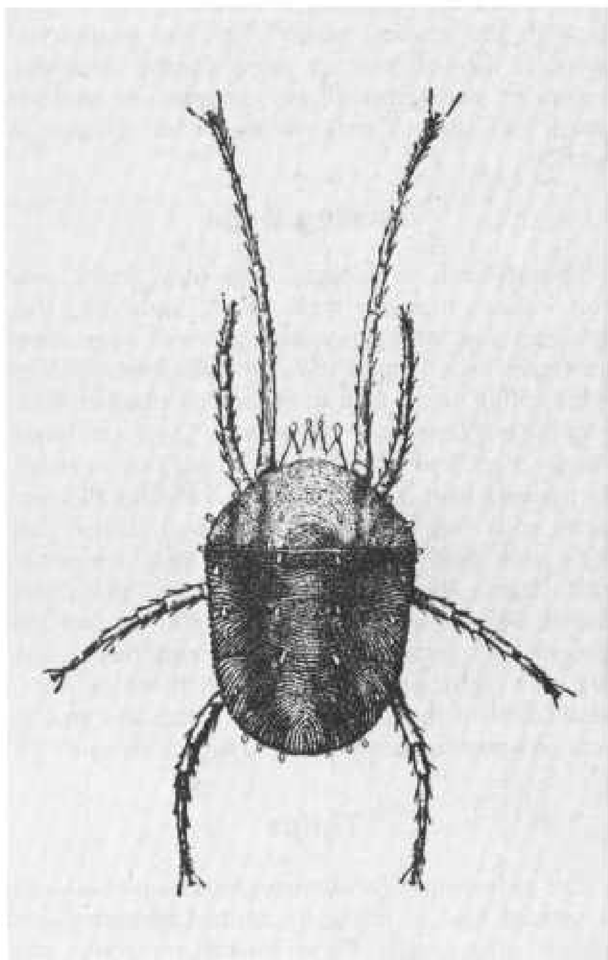


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Figure 18.—Brown mite adult.

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Figure 19.—Adult of pear leaf blister mite.

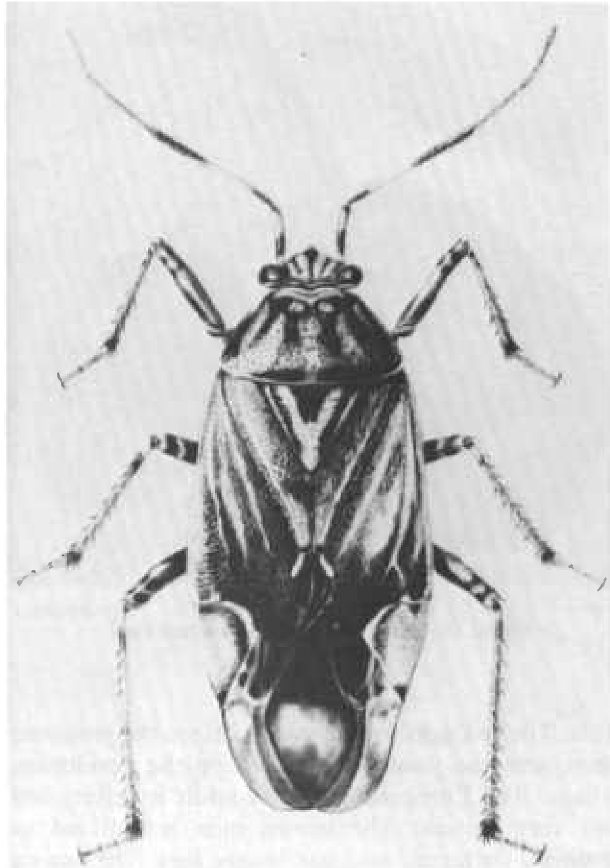

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Figure 20.—Lygus bug.

mites before fruit injury occurs requires careful examination of buds, leaves, and fruits with a high-power hand lens or under a dissecting microscope. As with the pearleaf blister mite, the postharvest period is the best time to apply control measures. However, delayed-dormant, prepink or summer sprays may also be required to prevent damage to the fruit.

Sucking Bugs

Several kinds of sucking bugs may attack pear fruit. Among these are lygus bugs (*Lygus* spp.) (fig. 20). They are small, grayish or greenish bugs about one-fourth inch long. They may cause buds to drop in the spring or the fruit to become misshapen. Boxelder bugs (*Leptocoris trivittatus* (Say)) are larger and are black and red. They are more likely to attack the ripening fruit. The stink bugs, including the consperse stink bug (*Euschistus conspersus* Uhler) and Say's stink bug (*Chlorochroa sayi* Stal), are somewhat larger, about one-half inch long and shield shaped. The consperse stink bug is gray- brown and covered with small black dots whereas Say's stink bug is bright green covered with white dots. Infestations of these sucking plant bugs are usually local and may occur anytime during the season.

Thrips

The pear thrips (*Taeniothrips inconsequens* (Uzel)) is usually held in check by control measures used against other pests. These insects are about one-twenty-fifth inch long, slim, and dark brown. The adults may be found in the opening buds, where they may prevent the blossoms from producing fruit. Later, the white larvae feed on the developing pears and cause russeting. Several other species, the bean thrips (*Caliothrips fasciatus* (Pergande)) and the western flower thrips (*Frankliniella occidentalis* (Pergande)), are occasional pests of pear in some areas of California. While the pear thrips and bean thrips have not been considered major problems in recent years, significant changes in pest control programs could result in the reappearance of these thrips as pests.

Other Insects

The orange tortrix (*Argyrotaenia citrana* (Fernald)) sometimes occurs on pears, particularly in the coastal districts of California. The active, greenish, black-headed caterpillars of this leafroller moth feed on the surface of the fruit. There are several generations a year.

The plum curculio (*Conotrachelus nenuphar* (Herbst)) is an occasional pest of pear in the Eastern United States. This weevil overwinters as an adult in fallen leaves and other debris in and around orchards. The adults become active in early spring and feed upon flowers, leaves, buds, and developing fruits. The eggs are laid in the fruit, and the developing larva feed inside. Damage consists of deformities caused by egg deposition punctures and feeding holes in the young fruit and feeding holes in mature fruit. In the northern areas, there is only one generation per year while there may be several in the southern areas.

The pear midge (*Contarinia pyrivora* (Riley)), resembling a mosquito, is a small insect that occurs in the Eastern States. It emerges when the blossom buds begin to show color and deposits eggs in them. The eggs hatch in a few days, and the small whitish larvae feed in the developing ovaries, causing the young fruit to be deformed. When full grown, the larvae leave the fruit and enter the soil to spin cocoons, in which they remain until they transform to adults the following spring.

The pearslug (*Caliroa cerasi* (L.)) (fig. 21) is slimy, olive green or black, and about one-half inch long when full grown. These slugs feed on the foliage. Other leaf feeders include a tentiform leaf miner (*Lithocolletis* sp.), the California pear sawfly (*Pristiphora abbreviata* (Hartig) (fig. 22), the spring cankerworm (*Paleacrita vernata* (Peck)), and the fall cankerworm (*Alsophila pometaria* (Harris)). All these leaf feeders are likely to be controlled with spray programs used against the codling moth and the pear psylla.

Aphids are occasionally found on pear, including the woolly pear aphid (*Eriosoma pyricola* Baker & Davidson), the melon aphid (*Aphis gossypii* Glover), the apple aphid (*A. pomi* DeGeer), the green peach aphid (*Myzus persicae* (Sulzer)), and the bean aphid (*A. fabae* Scopoli). Control of aphids is usually not difficult.

The shothole borer (*Scolytus rugulosus* (Ratzeburg)) may also be found in pear trees, usually those in poor condition. The American plum borer (*Euzophera semifuneralis* (Walker) and the Pacific flatheaded borer (*Chrysobothris mali* Horn) may also attack trees in poor condition. Keeping trees healthy will prevent most of these attacks.

BN-29827

Figure 21.—Pear-slug and its injury.

The grubs of rain beetles (*Pleocoma* spp.) attack the roots of pear in Hood River County, Oreg., and occasionally elsewhere. They are whitish with brown heads and may be 2-1/2 inches long when full grown. The buffalo treehopper (*Stictocephala bubalus* (F.)) and other species attack young pear trees in northern California and in the Northwest. Injury to the bark results when the females slit it to lay their eggs. Clean cultivation about the trees will usually prevent most of this injury.

PEAR DISEASES

Fire Blight

Fire blight is one of the most destructive pear diseases. Losses vary from blossom blight to destruction of large branches and entire trees. The extent of damage depends on such factors as varietal susceptibility, weather conditions, cultural practices, and control measures.

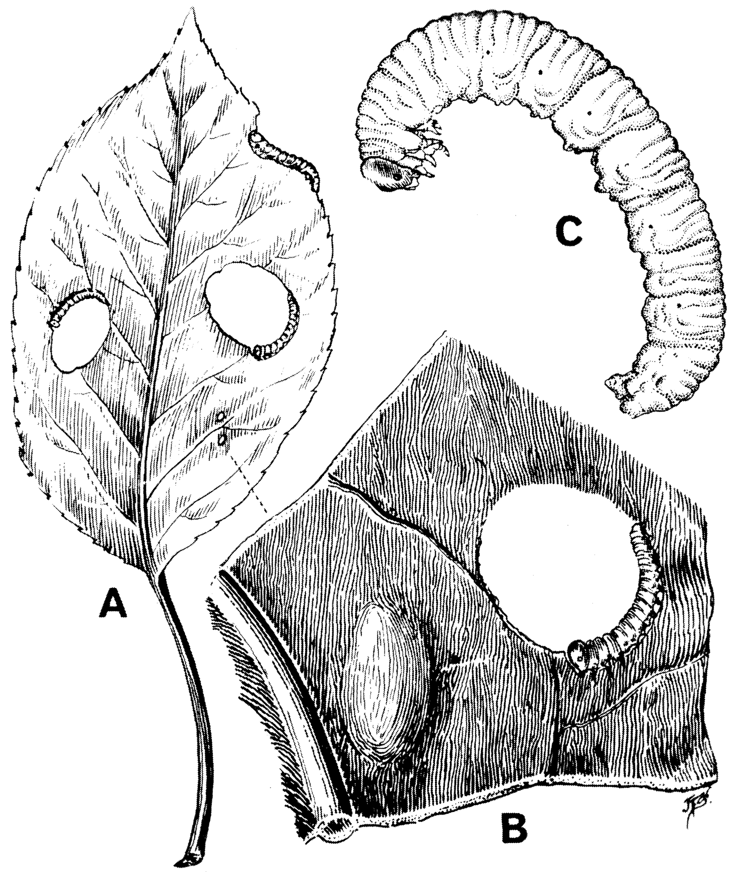

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Figure 22.—California pear sawfly: *A*, Injury to leaf; *B*, egg in tissue and young larva feeding; *C*, full-grown larva.

The disease was first recorded in the Hudson River Valley of New York in 1780. Nearly 100 years later the bacterium, *Erwinia amylouora,* was found to be the causal agent.

The disease usually appears first as a blossom blight (fig. 23 *A*). Later, infection spreads to shoot growth and developing fruit (fig. 23 *B*). The blossom-blight symptoms are confused in some areas with those caused by *Pseudomonas syringae.* As the bacteria invade the spurs and branches, the tissues turn dark green and become water soaked. Affected parts eventually turn brown, then black, and usually remain firmly attached to the tree. Under favorable conditions, the bacteria move very rapidly. If left unchecked, they advance from the blighted blossoms to the main branches, down the trunk (fig. 23 *C*) and into the roots. In Beltsville, Md., many Magness trees have died from blight that started in the trunk and later girdled the entire tree. The bacteria may overwinter in cankers, which may act as inoculum sources the following spring. Affected parts often produce droplets of clear, milky, or amber-colored exudate. Numerous bacteria, contained in the exudate, are readily disseminated to susceptible tissue by insects.

Insects disseminate the bacteria. Honey bees contaminate their bodies by visiting blighted blossoms and are often responsible for carrying the pathogen from blighted to healthy flowers. Other insects may also cause blossom infections by accidental contact with bacterial exudate followed by later visitation to flowers.

Rain and windblown mist transfer bacteria from diseased to healthy plant parts. Blight epidemics often follow hail storms. Injury caused by hail apparently provides entry points for the bacteria. Any means involving physical transfer of the bacteria to susceptible plant parts can also spread blight, provided other conditions are favorable. Control measures are designed to reduce innoculum and protect susceptible tissue.

PN-5768

Figure 23.—Fire blight of pear: *A*, Severe blossom blight; *B*, advanced fruit blight, showing typical water soaked margin along necrotic area with many ooze droplets; and *C*, characteristic streaking on tree trunk, resulting from profuse production of bacterial ooze.

Control usually necessitates removal of all infected spurs and branches as soon as they appear. Affected areas on large branches, crotches, trunks, and roots, should be removed immediately, regardless of size, to prevent spread to healthy parts of the tree. Cuts should be made well below the infected areas to insure removal of all tissue which might contain fire blight bacteria. In these operations, cutting tools should be disinfected between each cut to prevent possible transmission of the causal organism.

Mercury compounds are no longer allowed for use as disinfectants. Household chlorine bleaches containing 5 percent sodium hypochlorite diluted to one-tenth of the proprietary strength, are more convenient, easy to obtain, and satisfactory. However, sodium hypochlorite is extremely corrosive to metal. Other disinfectants include various denatured alcohols. Pruning tools are either dipped or wiped with a sponge that is saturated with the disinfectant between each cut. All tools treated with disinfectant should be thoroughly rinsed and dried when reuse is not anticipated within several hours. Infected wood must be removed from the orchard after pruning and burned promptly.

Helpful preventive measures include removal of all root suckers and succulent water sprouts that might become infected and carry the bacteria into the body of the tree. Cultural and pruning practices that discourage vigorous growth tend to reduce susceptibility to fire blight. Overstimulation of growth by fertilization should be avoided.

Application of chemicals in sprays or dusts has aided in blight control when used in combination with other control measures. Various forms of copper have been recommended for fire blight control. Bordeaux mixture has provided relief from the disease on pears. However, its value on apple for fire blight control has been less beneficial. All coppers, even the fixed forms, have been effective in certain localities, but may russet some varieties. Dust formulations often have been less injurious than spray applications with the same chemicals. Anjou is especially sensitive to copper, and in recent years antibiotics have provided more satisfactory control on this variety.

Streptomycin has provided very effective control of fire blight in Oregon and California on the highly susceptible variety Forelle. In Maryland, a 6-year field study showed that, under epiphytotic blight conditions, fire blight in Bartlett pears could be controlled with streptomycin. However, resistance to antibiotics has been reported and local authorities should be consulted before using them for fire blight control. *No single practice will control fire blight, but a combination of all available practices will undoubtedly reduce damage.*

Most of the commercially grown pear varieties are susceptible to fire blight. More than 100 species of the family Rosaceae are hosts of the disease. However, sources of resistance are known in pears and apples, and plant breeders have developed new varieties with commercial potential. The widely grown Bartlett variety is one of the most susceptible and cannot be grown commercially in the warmer areas of the United States.

Fire blight is the most serious disease affecting pears and limits the production of the older high-quality varieties to the cooler growing areas of the Pacific Coast, the higher elevations in the Mountain States, and small areas along the Great Lakes. Even in these areas, much effort is necessary in the use of blossom sprays, prompt canker removal, good growing practices, and community cooperation to keep the disease in check. A comprehensive review of fire blight was recently completed and is included in the selected reading material listed in back of this handbook.

Pseudomonas Blight

Another frequently troublesome bacterial disease of pears is caused by *Pseudomonas syringae* (fig. 24). This disease has been known by many names, including blossom blast, lilac blight, false fire blight, and Pseudomonas blight. The latter is preferred because it distinguishes this disease from fire blight. These two diseases bear striking similarities, particularly in the blossom stages of infection. However, they can be readily separated by following the progress of symptoms beginning with the initial stage of infection.

Bacterial ooze is not normally associated with infection by *P. syringae,* but an unidentified fluorescent *Pseudomonas sp.* was isolated from infected pear buds in 1969 by researchers in Beltsville, Md. Therefore, this characteristic is no longer a reliable means of separating fire blight symptoms from those of Pseudomonas blight.

BN-29820

Figure 24.— *Pseudomonas* canker on stem of young Bartlett tree.

In California, Pseudomonas blight is reported to cause brownish streaks, which extend several inches through the cortex and outer phloem beyond the outwardly visible canker. Similar streaks are rare or entirely lacking when the wood is invaded by fire blight bacteria. In apple, however, it was observed in New York that discolored streaks extended in the xylem in advance of externally visible lesions following artificial inoculation. Although *P. syringae* has commonly been associated with pear trees, the most crucial period for protection of the plant against invasion by the bacterium has not been established. The literature on *P. syringae* suggests that both spring and fall infections occur. Systemic invasion of the tree may result from infection at any time and pathogenic *P. syringae* bacteria have been isolated from apparently healthy pear trees. Systemically infected trees make control measures extremely difficult. Therefore, young trees must be adequately protected during periods of cool, wet weather because these conditions are most favorable for disease development.

Control of the disease in the Pacific Coast States has been based on the theory that most of the infection occurs in the fall and application of two bordeaux sprays is commonly recommended. The first spray should be applied when the leaves begin to fall and the second when most of the leaves are gone. Early spring sprays, applied while the trees are still dormant, may also be helpful. However, their use should be restricted to young, nonbearing trees to avoid injury to the fruit of copper-sensitive varieties. Antibiotic sprays have not proven successful, and treatments more effective than copper are needed.

Symptoms of Pseudomonas blight typically begin as one or more minute, black lesions on the flower parts. The lesions enlarge, turn black very rapidly, and often coalesce to form larger necrotic areas. In contrast, infections which result from invasion by fire blight bacteria begin at the nectiferous tissue of the flower and spread rapidly through the calyx cup and into the receptacle. They continue to move rapidly into the spurs and branches. The affected parts develop a dark-green, water-soaked appearance, but later become dark brown and often appear shiny as the bacterial ooze dries on the surface of the infected tissue. Calyx cup infections due to *P. syringae* are common and may occur independent of blossom blast.

Both Pseudomonas blight and fire blight are favored by moist conditions, but optimum temperatures for disease development vary markedly. Fire blight is generally favored by higher temperatures than Pseudomonas blight, and exposure of pear blossoms to frost has been shown to cause a marked increase in their susceptibility to *P. syringae*. Conversely, fire blight development is delayed by the intervention of frost during the blossom period. The differential response to frost may help explain the often sporadic development of these two diseases in fruit-growing areas.

Scab

Scab, caused by *Venturia pyrina* (fig. 25), is an important disease of pears in some areas of the

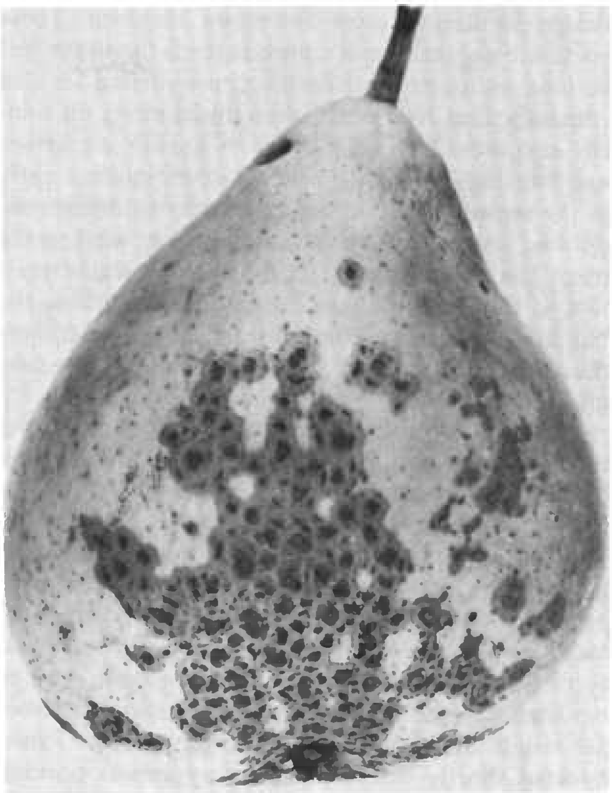

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Figure 25.—Pear scab.

United States, and when control measures are not practiced, losses are high. Its severity is dependent upon environmental conditions and spore carryover from the previous year.

The general appearance of pear scab is similar to apple scab, a disease caused by the closely related fungus *V. inaequalis*. Leaves, fruits, and succulent young twigs are susceptible to attack. During seasons when rainfall is abundant at bloomtime, dark, velvety, or sooty spots begin to appear on the young fruits about petal fall. Fruits infected early usually drop, whereas those infected later remain on the tree and may be severely misshapen by harvest time. Malformation of the fruit is caused by cessation of growth in the region attacked by the fungus while healthy tissue continues growth. Early infections may cover the entire side of the fruit, whereas later infections usually result in numerous small spots. The area in the center of a scab lesion may die and slough off, leaving a russeted area on the skin. This corky area is commonly surrounded by sooty patches of active scab at the edge of the lesion.

Leaves often display dark, velvety patches of the fungus similar to those found on the fruit. These spots are generally more prevalent on the lower leaf surface, although spots on the upper surface are also common. Leaf lesions are often found along the midrib, and as the affected part ceases growth, puckering and twisting commonly occur. Leaves infected early in the season usually drop, and under epidemic conditions, severe defoliation may seriously weaken the tree. The remaining infected leaves decrease their rate of food manufacture and contribute little to the buildup of reserves. Consequently, bud formation is decreased, and the next year's crop may be adversely affected.

Infection of twigs may occur at any time during the growing season. New twig lesions appear as small blisters or pustules, which often slough off as the twig produces a corky underlayer. The remaining pustules are an important source of inoculum the following spring. Overwintering pustules rupture during moist weather in the spring and liberate spores (conidia), which are readily dispersed by rain and wind to cause new infections. The infection cycle may be repeated several times during the growing season, and fruits are susceptible until harvesttime. Fruits infected shortly before harvest may appear normal, but often develop small pinpoint lesions during the storage period. Infection of the fruit after harvest has not been demonstrated.

Most features of pear scab are similar to those of apple scab. In addition to the production of conidia (summer spores), the fungus also produces perithecia on fallen leaves and in infected twig lesions. The perithecia mature during the winter and early spring and develop ascospores, which are forcibly discharged and carried about by air currents during moist weather.

Continual moisture is necessary for spores to germinate and cause infection. At the optimum temperature (75° F or 23.9° C) for growth of the pear scab fungus, a continual wet period of 5 hours is adequate for the infection process to proceed. At higher or lower temperatures, a correspondingly longer continuous moist period is necessary at 40° F (4.4° C), 48 hours is required to establish infection. An incubation period of 12 to 25 days is required for the fungus to become visible to the naked eye. This accounts for the appearance of the disease at times which may appear unfavorable for its development.

All commonly grown commercial pear varieties are susceptible to scab. Bosc fruits are very susceptible in the immature stages, but become highly resistant after they have shed their pubsecence. It is not uncommon for a variety to be severely affected in one area and only lightly affected in another. This may be due to the existence of fungus strains which vary in their pathogenicity. The occurrence of such strains has been reported in the United States and thus would account for apparent differences in varietal susceptibility.

Control of this disease is complicated by the overwintering of the fungus on current-season twig growth, in contrast to the apple scab fungus, which overwinters exclusively on the fallen leaves. Plowing under the fallen pear leaves was recommended as a control measure in Australia, where it was demonstrated that leaves buried for 70 days were no longer capable of producing ascospores. Control measures in the current season are designed primarily to protect young fruits and leaves as they develop. Early season efforts are imperative to successful pear scab control.

Many control schedules recommend the application of lime sulfur in the dormant period just as buds begin to swell. Lime sulfur, ferbam, and dodine are fungicides most commonly recommended during the early spring and into the growing season. Dodine has been more effective and less injurious than other materials after the dormant spray. Reports of apple scab fungus resistance to dodine are common, and the occurrence of similar resistance by the pear scab fungus would not be surprising. Local authorities should be consulted before planning a spray program to determine which control methods and materials have provided satisfactory control in any given area.

Root Disorders

Various root diseases are found in most pear-growing regions of the United States and have been referred to as collar rot, crown rot, and root rot. The primary pathogens are several species of the fungus *Phytophthora*. Collar rot was reported on pear trees in British Columbia in 1959 where it was shown that *P. cactorum* was the causal agent. More recently, it was demonstrated that two other species of *Phytophthora* (*P. cryptogea* and *P. cambivora*) were capable of infecting pear rootlets. Research in Oregon showed that *P. cinnamoni* was pathogenic on pear roots.

Trees infected by species of *Phytophthora* are characterized by generally poor growth. Those attacked by *P. cactorum* may eventually die because of a girdling of the trunk at or below the ground line. *P. cinnamoni* kills young feeder rootlets, but is not pathogenic on the larger roots and crown tissue. Nursery stock infected with *Phytophthora* often results in a high percentage of unthrifty trees, which commonly produce little or no growth for several seasons after planting.

Although differences in varietal susceptibility have been observed, little information on the subject is available. Oregon reports indicate that a lower percentage of infection occurs in Old Home, Old Home X Farmingdale seedlings, and *Pyrus calleryana* than in Winter Nelis and Bartlett. Until more research on varietal susceptibility is completed, control measures are dependent on means other than resistance.

Collar rot losses can be reduced if the disease is detected before damage to the cambium occurs. Infected tissue should be exposed to the air and allowed to dry thoroughly. The area adjacent to the trunk should be kept free of weeds and debris so that rapid drying will occur after rain or irrigation. However, these practices would be of little value where young rootlets are rotted by *P. cinnamoni.*

In Washington, where collar rot is frequently a severe problem in pear orchards, soil should be temporarily removed from the crown area of infected trees in early spring. This practice may check the progress of collar rot and enhance recovery of the tree if it is completed during the early stages of infection. The soil should be replaced as the trees enter the dormant season to reduce exposure of the crown area during the winter months. Irrigation should be carefully managed during the growing season, and extended wetting of the crown should be avoided. Successful control of collar rot depends primarily on the maintenance of well-aerated soil and prevention of free-water accumulation. Chemical control of collar rot has met with little success but treatment of the crown area with copper sprays or paints has been recommended. Although the fungus is especially sensitive to copper, these treatments should not be repeated at frequent intervals because copper may accumulate in the soil and cause phytotoxicity.

Armillaria root rot, also known as oak root fungus, crown rot, and shoestring root rot, is caused by the fungus *Armillaria mellea.* The disease is not generally considered an economic problem, but in some localities it is troublesome. Pear trees of all ages are susceptible to attack by the fungus. Masses of fungus mycelium, known as rhizomorphs, penetrate the root of the host plant. These structures attach themselves to the host root and apparently enter through a combination of chemical and mechanical means. The rhizomorphs grow rapidly throughout the root between the bark and the wood, forming a white fingerlike growth. Large areas of the root are killed by the action of the fungus, and as the crown becomes girdled, the tree declines and eventually dies.

The fungus can live saprophytically in the soil or may parasitize a wide range of host plants. Resistance to *Armillaria* is known, but resistant rootstocks are not used in commercial pear growing for control of this disease. Soil fumigation with chloropicrin or carbon disulfide has been successful on light soils, but only provides partial control on heavier soil types. When practical, newly cleared forest land should be avoided for new pear plantings if *Armillaria* infected hosts previously occupied the area.

Powdery Mildew

Powdery mildew of pears is caused by *Podosphaera leucotricha.* Although this fungus is more common on apples, it is readily spread from this host to pears. The fungus commonly overwinters on infected apple buds and is disseminated to pears in the spring. In Oregon, the fungus is capable of overwintering on infected buds of pear seedlings and invades the new shoots as they develop. Infected tissue becomes covered with a white, fluffy mycelial growth, on which conidia (spores) are borne. These spores can infect tender young fruits, leaves, and shoots. The disease cycle may be repeated every 5 to 7 days under ideal environmental conditions. The optimum temperature for disease development is 70° F (21° C). Most fungi require free water for spore germination and continued development, but water inhibits germination and growth of the pear powdery mildew fungus. However, relative humidities between 95 and 99 percent do favor this disease.

Symptoms on pears are identical to those on apples, but often mycelial growth and spore production are more limited. Buds weakened by powdery mildew are more susceptible to winter damage and are often severely injured during cold weather. Early infection of the young fruit may cause serious russeting and render it unsalable by harvesttime.

Control of powdery mildew is usually achieved by several fungicide applications beginning at the pre-pink stage. Lime sulfur and various other sulfur compounds are sometimes used for powdery mildew control on pears. However, sulfur fungicides may reduce fruit set of Anjou when applied after the buds begin to open in the spring.

Dinocap is more commonly used for control of powdery mildew of pears, but recommendations of local authorities should be followed closely. *Under no circumstances* should dinocap be applied during the full-bloom period because this fungicide may interfere with pollination. Sprays to control powdery mildew should be applied immediately after petal fall. In the Pacific Coast States, two spray applications at a 10 to 14-day interval should provide economic control of the disease and reduce fruit russet due to fungus infection, unless conditions are extremely favorable for powdery mildew development. Spray recommendations in Oregon include a combination of dinocap, dodine, and streptomycin during the postbloom period to control powdery mildew, scab, and fire blight. Serious fruit damage may result from the use of dinocap plus streptomycin during the postbloom period if dodine is omitted from the combination. Therefore, dodine should always be included in the mixture, even if scab is not a problem.

Leaf Spot Diseases

Two leaf spot diseases of pear are found throughout the United States, but more frequently are troublesome in areas east of the Mississippi River. Early leaf spot is caused by the fungus *Fabraea maculata* and appears in early spring (usually April). The spots are mostly circular in outline and dark brown to nearly black with purplish margins. Spotted leaves turn yellow and drop, often causing profuse bloom in early fall. The fruits of some varieties such as Garber, may develop black cankers and cracks after infection.

Late leaf spot is caused by *Cercospora minima.* Symptoms usually appear in August as indefinite, angular, brown to grayish spots without definite outline and follow the areas between major veins. Severe infection by *C. minima* may defoliate pear trees.

Ferbam sprays control early blight and should be applied when the spots begin to appear in April, followed by one or two sprays at 3-week intervals. Late leaf spot may be controlled with a similar spray program, with application of the first spray in late July. Copper sprays should be used only in severe infection because of risk of fruit russet. Sanitation measures, such as plowing under or removing fallen leaves, help to reduce the incidence of these two leaf spot diseases.

Physiological Disorders

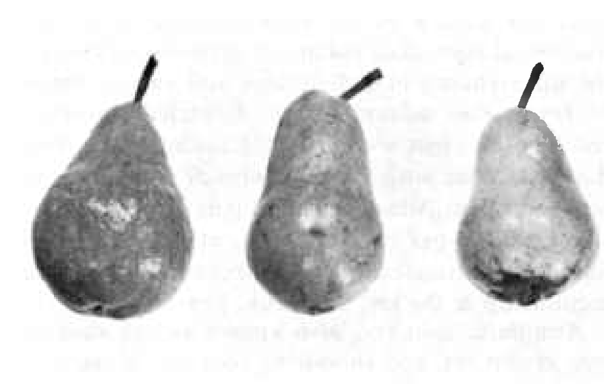
Hard End

Hard end or black end makes fruit hard, rounded, or often black over the blossom end as it approaches maturity (fig. 26). This disorder occurs almost exclusively on trees propagated on oriental stock. It is generally attributed to unfavorable water relationship within the plants and fruits. The ability of the Japanese rootstock to supply water to the scion is reportedly less than that of the French stock. If this is the case, an intense competition for water may exist among the organs of the Japanese rooted trees during hot periods when water loss is excessive.

Hard end has ceased to be a serious problem in western pear culture, since most of the trees on susceptible stocks have succumbed to pear decline. The disorder may be largely avoided by using the proper rootstocks (see table 7).

Cork Spot of Anjou

In certain instances, Anjou pears develop a serious fruit disorder known as cork spot. Affected fruits develop internal necrotic spots, which are often associated with external sunken areas, giving the fruit a bumpy appearance (fig. 27). Such pears are unmarketable. Frequently, insufficient symptoms on the surface prevent detection when the fruit is graded.



PN-6365

Figure 26.—Bartlett pears showing two stages of hard end disorder: *Left*, Normal; *Center*, hard end; *right*, black end. After Ackley; see "Suggested Supplemental Reading."

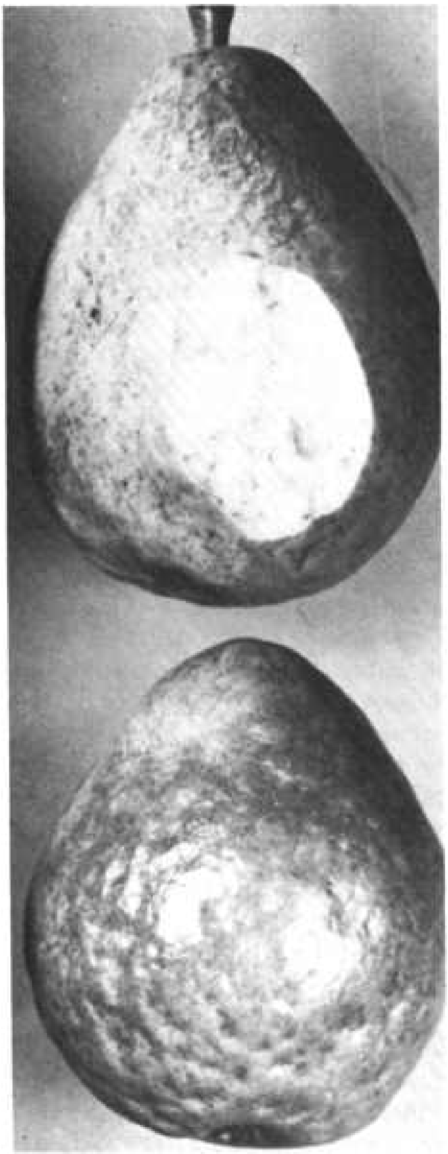


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Figure 27.—Cork spot of Anjou.

Cork spot is more serious when trees are propagated on oriental roots. Relatively light crops of large fruits are more prone to develop the disorder. In this respect, cork spot is similar to bitter pit in apples. During periods of moisture stress (hot days), the leaves apparently pull moisture from the fruit, resulting in the death of cells in the flesh and the formation of cork spots. Cork spot can be largely avoided by the use of French rootstocks and the employment of cultural practices that will be conducive to a heavy set of fruit.

Virus Diseases

Virus diseases are a major threat to the pear industry and losses may take various forms. The overall effects of virus infection in pear trees often involve a reduction in tree vigor, fruit quality, and yield. Virus diseases of pear have not been studied as thoroughly as those of stone fruits and apples, but various investigators have shown that several viruses attack pears and present serious problems for pear growers.

Stony pit was the first virus described on pear trees. Many other virus-induced diseases of pear have since been reported, including those which cause leaf mosaics, bark disorders, and fruit blemishes. More recently, several latent (symptomless) virus diseases of pear have also been described.

Pear vein yellows is probably the greatest threat to the pear industry because it is widely distributed, severely affects young trees, and causes a significant reduction in yield. A 13-year study in England revealed that trees infected with pear vein yellows produced 30 percent less fruit than healthy trees. A 40-percent yield reduction occurred when trees were infected with both pear vein yellows and ring pattern mosaic (apple chlorotic ring spot). Several latent viruses have also been reported in pear trees. Viruses in this group produce no detectable symptoms in pear, but when isolated from pear and inoculated to indicator hosts, produce symptoms which are readily recognized. Although pear decline was previously described as a virus disease, it is now believed to be caused by a mycoplasmalike organism and will be discussed separately.

Transmission of pear viruses by insect or nematode vectors is sometimes offered as an explanation for apparent spread of these diseases in the field. However, no experimental evidence has been reported to confirm these observations. Because vegetative propagation is the only proven method of transmitting virus diseases from one pear tree to another, extreme care should be exercised in the selection of material for this purpose. Although reports of seed transmission of pear virus diseases have appeared in the literature, they are not confirmed by further experimental evidence. The following descriptions of several pears viruses should be helpful in recognizing these diseases as they exist in the orchard. It is not intended as a complete list of all virus diseases on pears.

Stony Pit

Stony pit is characterized by stony tissue in the pear fruit, usually at the base of dimples and depressions. Severely affected fruits are misshapen, malformed, and unsalable. The abnormal tissue develops early in the growth of pear fruits. Dark-green areas are formed just beneath the peel 10 days to a month after petal fall. Rapid development of surrounding normal tissue results in depressions or pits. When several of these occur together, pear fruits become drastically distorted. Cutting into the pitted area reveals stony masses of grit cells. The severity of stony pit symptoms is variable among fruits on an affected branch of an infected tree and among individual trees in an orchard. Symptom severity may vary from one year to the next on an individual tree, but the relationship of symptoms from tree to tree will usually remain constant. Stony pit symptoms should not be confused with those caused by the tarnished plant bug (*Lygus lineolaris*), cork spot, or boron deficiency.

Chlorotic flecking, leaf banding, and rough bark symptoms have also been associated with stony pit-infected trees. However, in most cases, these symptoms probably are caused by other viruses, which may occur concurrently with the stony pit virus. Bosc is the most severely affected, but symptoms also appear on Anjou and other varieties. Although Bartlett fruits rarely display stony pit symptoms, they have been observed on this variety in Oregon and California. This suggests the possibility of a new strain of the virus, since it has been common practice to topwork infected Bosc and Anjou trees to Bartlett. This recommendation was made when it was discovered that Bartlett did not express stony pit symptoms following budding or grafting of trees severely infected with the virus. The maintenance of a virus reservoir in the orchard is not good management, and infected trees should be replaced as soon as practical. No method for reducing the severity of symptoms or curing infected trees in the orchard is known.

Leaf Mosaics

Pear vein yellows virus causes chlorotic bands to form along the smaller veins of infected leaves. Usually, only short sections of the veinlets are affected, and the symptoms are most pronounced during the scion's first year of growth. Mature trees do not ordinarily display symptoms. Red mottle virus of pear causes similar symptoms except that the affected areas develop red coloration due to necrosis of the cells. Whether this is caused by a strain of vein yellows or is the result of infection by two different viruses is uncertain. Sources of vein yellows without red mottle have been discovered, but no material has been found to be infected with red mottle and free of vein yellows. Local environmental conditions have a marked influence on symptom expression in pear trees infected with the virus. Although seed transmission was reported for this disease, it has not been confirmed. Only grafting techniques are well documented as methods of transmission of the virus.

Most of the commonly grown commercial varieties are susceptible, but do not display symptoms of equal intensity. Various surveys have shown that pear vein yellows is widely distributed in commercial pear plantings in the United States and other countries. The substantial reduction in yield caused by pear vein yellows infection makes this disease of great economic importance to pear growers.

Pear ring pattern mosaic is caused by the same virus that induces the disease in apples known as apple chlorotic leaf spot. Infected trees produce leaves that are characterized by light-green to greenish-yellow rings and lines. The symptoms usually occur near the main or secondary veins, but most often appear completely at random over the leaf surface. The leaves of some of the more sensitive cultivars may be twisted or curled. Only rarely do symptoms occur in the fruits as faint green rings. No deformity of the fruit or damage to the flesh has been observed.

Transmission of the virus is readily accomplished by budding or grafting, and probably all pear varieties are susceptible. Surveys in The Netherlands indicated that 20 to 23 percent of pear trees tested in 1963 were infected with pear ring pattern virus. A survey conducted in Washington 10 years later did not reveal a single infected tree. The disease does not appear to spread in the field, and no effect on yield has been observed; however, it may reduce the grade in cultivars which develop symptoms on the fruit.

Other Virus Diseases

Several virus diseases of pear which cause disorders of the bark have been reported. Pear blister canker in England, pear rough bark in Norway, and pear bark measles in the United States cause similar symptoms in pear trees. All are transmissible from pear to pear. Although no comparative studies have been reported, these diseases may all be caused by the same virus or possibly by different strains of a single virus. The extent of damage caused by bark canker diseases is not known, but infected trees are typically poor producers and their growth is restricted.

Symptoms first appear as small blisters on the bark of 1- to 2-year-old stems during early spring. The bark later splits and cracks as the lesions enlarge and coalesce to form larger cankers. Young trees often succumb to attack by this virus. Those that survive for 3 years usually continue to grow, but may be stunted and unproductive.

These diseases are readily transmitted by budding and grafting. Therefore, it is essential that stock and scion varieties be virus free. Contrary to the reported seed transmission of pear bark measles, this theory is not generally accepted. Control measures for trees infected with the virus are not known.

Although other virus diseases have been reported on pears throughout the world, they either do not occur or are not of economic importance in the United States and will not be discussed here. Several latent virus diseases in pear have been demonstrated by indexing on suitable indicator plants. Very little information is available on the effects these viruses may have on their pear hosts, and they are not considered of practical importance to the commercial pear grower.

Disease Caused by Mycoplasmalike Organisms

Pear Decline

Although pear decline was previously described as a virus-induced disease, it is now known that a mycoplasmalike organism is the causal agent. Like a virus disease, this pathogen can be moved from pear to pear by budding and grafting. However, success by this means is generally low. The pear psylla (*Psylla pyricola*) can transmit the disease, and pear decline has historically followed introduction of this insect pest into pear-producing areas. The disease was first recognized in central Washington about 1946 and was reported in British Columbia in 1948.

During the next 10 years, pear decline spread to all pear-growing areas of Washington and was reported in Oregon in 1957. By 1959, it had moved to California. It spread rapidly in all these areas and thousands of trees were lost. Because pear decline causes the most severe reaction on trees grown on oriental rootstocks, the areas where these rootstocks were widely planted suffered the most severe losses.

The symptoms of pear decline parallel those of moria disease in Italy and the two diseases are probably identical. The causal agent was probably introduced into the United States on symptomless, nonsensitive stocks, where it may have existed for some time in the absence of a suitable vector. After establishment of the pear psylla in British Columbia and its subsequent migration to Washington, pear trees planted on sensitive oriental rootstocks readily developed pear decline symptoms.

Symptom expression on infected trees is also directly related to the sensitivity of the rootstock and to cultural care. Heavy infestations of pear psylla accentuate disease symptoms, while horticultural practices, which tend to reduce stress to the tree, generally result in less symptom expression.

Unlike diseases caused by viruses, control of the pear decline complex has proven feasible through the use of antibiotics. In California, over 300,000 trees are treated annually with oxytetracycline hydrochloride. The antibiotic is administered by transfusing it through small holes drilled into the trunk. Severely infected trees have been restored to normal or near normal condition following two to three annual postharvest treatments. This control method should not be used without first consulting experienced and qualified applicators. Oxytetracycline HCl, like other pesticides, must be registered for use on pears by State and Federal agencies before it can be legally used on pear trees.

Pear decline disease is characterized by the following three basic syndromes: quick decline or tree collapse, slow decline, and leaf curl. Both rapid and slow tree decline result from damage to the phloem tissue at the union of the stock and scion and are usually associated with trees on *Pyrus serotina* or *P. ussuriensis* rootstocks. Pear trees on the more tolerant *P. communis, P. betulaefolia,* and *P. calleryana* rootstocks usually develop leaf curl symptoms when infected with the pear decline organism. Leaf curl is characterized by leaves which curl downward from tip to midrib, develop a reddish to purple cast, and drop prematurely. Infected trees display leaf curl symptoms in late summer or early fall, well before healthy trees develop normal fall color. Other characteristic symptoms include poor shoot and spur growth and smaller leaves, which are typically rolled upward along the longitudinal axis. Infected trees normally produce fewer and smaller fruit than healthy trees and often develop extensive dieback of the branches.

Recent studies in California indicated that reduction in vigor of leaf curl infected trees may be due to causes other than stock scion incompatibility. Reduced translocation of soluble carbohydrates from the leaves was noted and may explain reduced vigor and productivity, as well as the difficulty often encountered in establishing young trees.

HARVESTING AND HANDLING

To attain highest quality, pears must be harvested before they are ripe. However, if picked when too immature, they are undersized and often shrivel in storage, lack sweetness and flavor, and are susceptible to storage scald. On the other hand, if picked too late, the fruit ripens quickly and has a short storage potential, is gritty in texture, lacks juiciness, and is subject to core breakdown.

Picking Maturity

Flesh firmness is the most satisfactory single index of pear maturity. The optimum picking pressure will vary somewhat under different growing conditions, but the pressure test is a valuable aid in determining the proper time for picking in any district.

Flesh firmness is determined with a Magness-Taylor pressure tester, which indicates the amount of pressure, in pounds, required to force a rounded plunger five-sixteenths inch in diameter into the pared flesh of the pear to a depth of five-sixteenths inch. The measurement should be made at two or three locations on the circumference of the fruit. Russeted and blushed areas should be avoided, because readings from them are usually higher than from other parts of the fruit. Recommendations for proper pressure-test readings for different pear varieties are listed in table 10.

Table 10.—Flesh-firmness recommendations for harvesting pear varieties

Variety	Firmness[1]		
	Maximum	Optimum	Minimum
	Pounds	*Pounds*	*Pounds*
Anjou	15	13	10
Bartlett	19	17	15
Bosc	16	13	11
Comice	13	11	9
Hardy	11	10	9
Kieffer	15	14	12
Seckel	18	16	14
Winter Nelis	15	12	11

[1] As measured by a Magness-Taylor pressure tester with a 5/16-inch plunger tip.

Other valuable indices of maturity, in addition to pressure tests, include color, corking of the lenticels, and general finish aid in determining proper picking time. Lenticels of immature pears are white and as cork cells develop, they become brown and shallow. The brown in the lenticels is a good indication that the fruit will ripen without shriveling. Color between the lenticels also becomes lighter green than at the lenticels. A characteristic waxiness of the skin and the rounding out of the fruit are also guides in determining the optimum picking maturity.

Of the various physiological tests for maturity, the soluble solids test is the most indicative of quality. A close correlation exists between flavor and soluble solids. In California, the Bartlett Pear Commodity Committee has established a combination firmness-soluble solids test in its maturity regulations. A pressure test of 21 pounds, reported to the nearest half pound, is the maximum allowable, and then only if the soluble solids are at least 10 percent. General picking may start at 20 pounds irrespective of solids content.

Bartlett is the variety commercially canned almost exclusively in the Pacific Coast States. Pears for canning are usually picked at a lower pressure-test reading than are those for fresh consumption. Canners usually specify the range of sizes and the grade, and the trees are selectively picked to meet requirements.

In the Pacific Northwest, Bartlett pears for canning should be picked at a pressure test of 15 to 17 pounds. These pressures ordinarily permit the harvesting of maximum tonnage, and the fruit is best suited for the storage and ripening procedures involved with processing. Pears picked at higher pressures darken more when cut and continue to darken during preparation for canning. At pressure tests of 14 pounds and lower, the pears tend to break down at the core before they reach the desired softness for canning. This tendency develops rather rapidly below 14 pounds of pressure.

Climatic conditions modify these figures for optimum maturity. Pears may soften very slowly during a hot season or in a hot production area, although they may change from green to more yellow shades and soluble solids may increase. In some California districts with hot, dry growing seasons, a desirable maturity may be reached when the flesh firmness is 21 pounds or slightly higher. In such cases, maturity indices, such as color, finish, and soluble solids, must be considered.

In cool districts or cool seasons and with ample moisture, pears tend to be softer and greener than those grown in hotter districts, especially if there is a shortage of water. Pears grown in hot weather tend to be yellow and remain firm in texture.

Abnormally cool growing seasons can also affect the harvest date. Premature ripening of Bartlett pears in the Hood River area occurs in districts with comparatively cool growing seasons and only in years when temperatures are below average. The several weeks before harvest were more critical than those earlier in the growing season. The earliest indication of premature ripening in the orchard appears as pink coloration near the calyx. Affected fruits soften and break down in the core area and fail to ripen normally. Premature ripening is induced by continuous exposure of pears to 45° F (7.1° C) or colder night temperatures and 70° F (21° C) day temperatures for 2 days or 50° F (9.9° C) night and 70° F (21° C) day temperatures for 9 days during the month immediately preceding harvest. Premature ripening does not develop with night temperatures of 55° F (12.6° C) and 70° F (21° C) days, or 45° F (7.1° C) nights and 90° F (32.1° C) days. When premature ripening first appears on a few of the fruits, the crop should be harvested, and even though firmer than recommended, the fruits may be handled normally and will usually ripen to fair quality.

Packing

Pears destined for immediate consumption on the fresh market may be packed and shipped without precooling or without being held in cold storage before shipping. This fruit should arrive on the market in a condition that will quickly reach the eating-ripe stage.

For pears that are not to be shipped immediately after harvest, the best practice is to pack them as they come from the orchard and cool to a core temperature of 29° to 31° F (-1.6° to -0.6° C) to arrest ripening. However, packing operations often cannot keep pace with harvest, and accumulated pears should be placed immediately in cold storage and packed as promptly as is feasible.

Bartlett pears promptly cooled and held at a core temperature of 31° F (-0.6° C) for up to 4 weeks are not susceptible to surface blemishes. With prompt and adequate refrigeration, the packing season for Bartlett pears may be safely extended for 4 to 6 weeks and for Anjou pears, 12 to 16 weeks after the fruit has been picked. Fruit handled this way can be washed and packed without previous warming.

Most of the pears are wrapped and place packed in two-piece full-telescoping corrugated fiberboard containers. Some are wrapped and tray packed in slightly deeper, two-piece, full-telescoping corrugated fiberboard containers.

A "tight fill" fiberboard box is also used commercially, chiefly for Bartlett pears in California. It is a laborsaving pack in which the boxes are filled from the ends of belts and tightly packed by vibration. Box lids, fixed by staples or other means, produce a compressed pack, which prevents movement of the pears in handling and transit.

Nearly all pears destined for the fresh market are packed in vented polyethylene liners, which minimize moisture loss but do not induce carbon dioxide levels that would injure the pears.

The Hartman wraps contain copper to prevent spread of decay organisms and ethoxyquin to control scald in Anjou. Ethoxyquin may also be applied in a flood applicator at harvest, as a line spray, or in wax at packing time.

Several types of decay, including Blue Mold, Bullseye Rot, and Side Rot, can be controlled by benomyl or thiabendazole applied in a flood applicator at harvest, in a line spray, or in wax at packing time. These materials do not control Mucor or Alternaria rots, so good sanitation and care in handling are very important.

As the packing season is extended, danger of siuffing and bruising increases. If it is necessary to store for more than a few weeks before packing, controlled atmosphere storage reduces the susceptibility to scuffing and bruising.

Storage

When pears are stored for a long time, they are cooled immediately after picking. If the fruit is consumed within a few weeks after harvest, immediate refrigeration is of less importance. For maximum storage life, pears are held at about 30° F (-1.1° C) in an atmosphere containing 2 percent oxygen and 1 percent carbon dioxide.

The length of time pears can be held in cold storage varies with the varieties. The storage life of each variety is fairly definite. When pears are held beyond their normal storage life, they will not ripen properly upon removal. Even though they appear to be in good condition, the flesh will not soften, the skin "scalds" or turns brown, and breakdown may occur.

The storage life of pears can be affected by several factors, such as conditions under which the fruit was grown, maturity at time of harvest, time lapse before being thoroughly cooled, and temperature in storage. Thermocouples may be placed in fruit and air at selected locations in the cold-storage room while the fruit is being placed in storage. Accurate records can then be obtained during the cooling and storage periods and the information used for adjustment of refrigeration capacity, air circulation, and stacking patterns.

Bartlett pears for canning, when held for 15 to 30 days in cold storage, have better color and texture when canned than either those ripened without storage or those stored for longer periods. However, fruit harvested at proper maturity and cooled promptly gives a fairly good product even when stored for 2 months before canning.

Some cold-storage operators are using a new technique to lengthen the storage life of Anjou pears by as much as 2 months. Immediately after harvest, the fruit is stored, but must be free of surface water. Carbon dioxide is then released in the storeroom until a 12-percent concentration is reached. The oxygen in the storeroom will level off and should be maintained at 12 to 15 percent. Fans should be used to prevent carbon dioxide layering. After 2 weeks, the oxygen and carbon dioxide must be reduced to the normal storage concentration of 2-percent oxygen and 1-percent carbon dioxide to avoid carbon dioxide injury to the fruit.

Shipping

Pears should be shipped as near the recommended storage temperature as possible. Most rail carriers recommend thermostat settings of 33° or 34° F (0.5° or 1.1° C) because the equipment will not permit lower settings without danger of freezing.

Ripening

For best dessert quality, most varieties of pears should be ripened at 60° to 70° F (15.6 to 21° C) and a relative humidity of 80 to 85 percent. Ripening temperatures higher than 70° F (21° C) are not desirable and may result in poorly flavored and textured pears or in losses from decay before softening.

The fastest ripening temperature for Bartlett pears is about 75° F (23.8° C), but ripening at 68° to 70° F (19.9° to 21° C) is only slightly slower. The fruit ripened at the lower temperature may be slightly better flavored. It also ripens to excellent quality at 60° to 68° F (15.6° to 19.9° C), but for canning, the more rapid ripening may be desired because of the processing schedule. At a ripening temperature of about 85° F (29.3° C), quality is sacrificed and the pears often become mealy, whereas at higher temperatures they may fail to ripen and often break down. Kieffer pears should be ripened at 60° to 65° F (15.6° to 18.2° C).

Although pears may color and soften in storage, they cannot be assumed to have ripened normally unless they have developed full flavor and are very soft and juicy. The ability of pears to ripen depends on the storage temperature and the length of time they have been stored. Pears have a definite and limited storage life beyond which they will not ripen normally when removed to higher temperatures.

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